countercurrent stream of caustic soda solution. The sodium hydrosulfide solution which is formed is filtered and sold as a weak aqueous solution; concentrated and sold as a 70% aqueous solution; or concentrated further to a solid which is 73% sodium hydrosulfide.

In the second process, low molecular weight hydrocarbons are allowed to react with sulfur vapor to produce carbon disulfide and hydrogen sulfide. These gases are dissolved in caustic soda solution to form liquid carbon disulfide and by-product sodium hydrosulfide solution.

The by-product nature of some hydrosulfide productive capacity and also the possibility of easily converting sodium hydrosulfide into sodium sulfide by further reaction with caustic soda, make hydrosulfide capacities quite flexible.

b. Producers

There are currently six producers of high-quality sodium hydrosulfide operating a total of eight plants. These producers, their plant locations, and known capacities are given in Table 87. Stauffer Chemical Company accounts for 46% of identified capacity, and PPG Industries is second largest with 21% of identified capacity. The top three producers (including Occidental Petroleum) control 86% of hydrosulfide production.

Very little vertical integration into downstream products exists among producers of sodium hydrosulfide. Backward integration to raw materials exists in the case of some plants, but is generally fairly low. PPG Industries, for example, is basic in caustic soda and hydrogen sulfide. At Stauffer's Delaware City, Delaware, plant, sodium hydrosulfide is a by-product of carbon disulfide production.

c. Manufacturing Economics

In Table 88 we have shown estimated manufacturing costs for sodium hydrosulfide. Our estimates assume a plant representing a fixed investment of $1.3 million with an annual production capacity of 10,000 tons.

4. Supply/Demand Balance

Identified U.S. sodium hydrosulfide capacity has been well in excess of production for several years. For 1971 and 1972, production represented 57.5% and 48.3% of current identified capacity of 52,200 tons. These figures must be taken as approximations, however, for it is known that some capacity is not reported, and also that hydrosulfide capacity generally is quite flexible. For example, if demand for hydrosulfide is low, raw materials may often be diverted to production of other sodium-sulfur compounds such as sodium sulfide.

TABLE 87

SODIUM HYDROSULFIDE PRODUCERS

Company	Location	(Thousand Tons)	(% of Total)
Chemical Products Corp.	Cartersville, Georgia	2.5	4.8
Du Pont Industrial Chemicals Department	Linden, New Jersey	2.2	4.2
Occidental Petroleum Co. Hooker Chemical Corp. Subsidiary, Electrochemical and Specialties Division	Niagara Falls, New York	10.0	19.2
PPG Industries, Inc. Industrial Chemicals Division	Natrium, West Virginia	11.0	21.1
Stauffer Chemical Co. Industrial Chemicals Division	Delaware City, Delaware Dominquez, California	20.0 4.0	38.2 7.7
Witco Chemical Corp. Halby Division	Le Moyne, Alabama Wilmington, Delaware	1.5 1.0	2.9 1.9
TOTAL		52.2	100.0

SOURCE: Published estimates.

TABLE 88

ESTIMATED COST OF MANUFACTURING SODIUM HYDROSULFIDE (SODIUM SULFHYDRATE)

Physical Investment:	$1.3 MM
Capacity	10,000 Tons NaHS/yr
Operating Factor	3 Shifts/Day, 350 SD/yr

	Quantity/Ton	$/Unit	$/Ton
Variable Costs			
Raw Materials			
Sodium Hydroxide	0.714 tons	50.00	35.70
Hydrogen Sulfide	0.607 tons	17.50	10.62
Utilities			
Power	100 Kwh	0.0137	1.37
Steam	1.26 M lbs	1.00	1.26
Total Variable Costs			48.95
Semi-Variable Costs			
Operating Labor	1.33 men/shift	$4.31/m-h	4.82
Supervision	1 supervisor	$15,000/yr	1.50
Maintenance	5% of Investment/yr		6.50
Labor Overhead	60% of Labor and Supervision		3.79
Total Semi-Variable Costs			16.61
Fixed Costs			
Plant Overhead	40% of Labor and Supervision		2.53
Depreciation	11.1% of Investment/yr		14.43
Taxes and Insurance	1.5% of Investment/yr		1.95
Total Fixed Costs			18.91
TOTAL COST OF MANUFACTURE			**$84.47**

SOURCE: Contractor estimates.

5. Prices

In Table 89 we have shown actual versus list prices for sodium hydrosulfide, as well as total shipments and shipment values, for the period 1963 through 1972. The average unit value per ton is calculated from Commerce Department data for total shipments, and represents the industry average plant price. Examination of the data in Table 89 shows that in most years average plant price and total shipments are inversely proportional. This would indicate the existence of significant elasticity of demand in relation to price. List prices for flake sodium hydrosulfide have risen steadily since 1963 while average plant prices have fluctuated widely. In 1972, the last year for which data are available, the average plant price was 10% lower than in 1963. One possible explanation for the irregularity in average plant price may be reporting errors for some years in which data for lower-purity, lower cost sodium hydrosulfide are included with that of high-purity hydrosulfide.

S. SODIUM HYDROSULFITE

1. Summary

U.S. consumption of sodium hydrosulfite has risen from 28,300 tons in 1963 to 45,600 tons in 1972. This represents an average compound growth rate of 5.4% per annum. Foreign trade is small, with net exports typically amounting to about 3% of U.S. production.

Sodium hydrosulfite is used primarily by the U.S. textile industry for the vat dyeing of cotton and certain other cellulosic fibers. The importance of this application is likely to decline as synthetic fibers such as nylon and polyester continue to replace cellulosic fibers in textile materials. On the other hand, use of sodium hydrosulfite in wood pulp bleaching is likely to become more significant as it replaces zinc hydrosulfite in this application.

While there are few direct substitutes for sodium hydrosulfite in its major application, new fibers and new dye technologies are likely to lead to decreased consumption of this chemical by the textile industry. At the preent time, only small quantities of hydrosulfite are captively supplied within the industry.

There are currently five U.S. producers of sodium hydrosulfite. Three of these are large, multi-industry companies, and only one is not vertically integrated into some of the basic raw materials used in the manufacture of hydrosulfite. Forward integration among the five is insignificant.

Industry capacity has kept slightly ahead of total U.S. demand in recent years. The operating rate for sodium hydrosulfite production was 90% in 1971 and 88% in 1972. Although list prices have risen steadily,

TABLE 89

ACTUAL VERSUS LIST PRICES FOR SODIUM HYDROSULFIDE

Year	Shipments Quantity (Thousand Tons)	Average Value ($ Millions)	Average Unit Value ($/Ton)	Flake List Price ($/Ton)
1963	22.4	2.7	120.54	130
1964	24.1	2.9	120.33	130
1965	38.7	3.4	87.86	130
1966	42.4	3.8	89.62	133
1967	38.9	3.7	95.12	137
1968	32.2	3.4	105.59	147
1969	23.7	3.4	143.46	147
1970	28.1	3.8	135.23	147
1971	27.6	3.0	108.70	151
1972	24.8	2.7	107.25	151

SOURCES: U.S. Department of Commerce and Chemical Marketing Reporter.

the average actual plant price has been substantially less, and has increased only slightly since 1963.

2. Market Characterization

a. Market Size and Growth

Total U.S. production of sodium hydrosulfite in 1972 was approximately 47,000 tons. Although this was more than 12% greater than 1971 output, the average annual compound growth in production, from 1963 to 1972, was only 5%. Table 90 presents U.S. Department of Commerce production figures for these years, as well as data on foreign trade and U.S. apparent consumption of sodium hydrosulfite. In 1972, exports were mostly to Canada, with Viet Nam second; imports came mostly from Great Britain, with Japan ranking second. As Table 90 shows, foreign trade is small, and generally results in net exports representing approximately 3% of production. These net exports, in turn, reduce U.S. apparent consumption to a level which is generally about 97% of U.S. production. Thus, in 1972, U.S. apparent consumption of sodium hydrosulfite was 45,600 tons.

b. Uses

The major commercial value of sodium hydrosulfite lies in its power to chemically reduce a wide variety of materials. Thus, for example, "hydro" readily reduces metal ions to the free metal and reduces many dyes to the water soluble state required for dye application. (In the latter case, subsequent oxidation leads to permanent deposition of the dye on the fabric.)

For many years, the primary use for sodium hydrosulfite has been in vat dyeing of cotton, and, to a lesser extent, vat dyeing of other fibers. These vat dyeing applications accounted for 80% of U.S. consumption in the late 1960's, but represented only 70% of domestic use in 1972. In actual tons consumed, the 1972 figure is only a few percent higher than that of 1966. The outlook for this use of hydro is not bright. Synthetic fibers continue to gain increasing shares of the fiber market at the expense of cellulosic fibers, and new dye technology is leading to decreased consumption of hydro in the dyeing process.

As is shown in Table 91, other applications of sodium hydrosulfite include use in wood pulp bleaching, and in a variety of other bleaching, reducing, and stripping operations in the food, vegetable oil, and soap industries. The use of sodium hydrosulfite in wood pulp bleaching is likely to show increasing demand. This projecting is based on the expectation that sodium hydrosulfite will continue to replace zinc hydrosulfite as more stringent pollution guidelines limit zinc concentration levels in mill effluent, and also as domestic ore shortages continue to force zinc prices up.

TABLE 90

PRODUCTION, FOREIGN TRADE, AND APPARENT CONSUMPTION OF SODIUM HYDROSULFITE

(Thousands of Tons)

Year	Production	Imports	Exports	Apparent Consumption
1963	29.6	--	1.3	28.3
1964	31.4	--	1.8	29.6
1965	35.1	--	1.6	33.5
1966	39.9	--	1.3	38.6
1967	36.1	--	1.1	35.0
1968	40.0	--	0.6	39.4
1969	38.2	0.1	1.3	37.0
1970	42.2	0.4	1.8	40.8
1971	41.6	1.5	2.2	40.9
1972	46.7	0.7	1.8	45.6

SOURCE: U.S. Department of Commerce.

TABLE 91

SODIUM HYDROSULFITE USE PATTERN

(Percent)

	1966	1969	1972
Vat dyeing of cotton	67	62	72
Vat dyeing of other fibers	15	21	
Miscellaneous bleaching, dyestripping and reducing uses	18	17	12
Wood Pulp Bleaching	NA	NA	16
TOTAL	100	100	100

SOURCES: Trade publications and Contractor estimates.

c.   Substitute Products and Technologies

As discussed above, zinc hydrosulfite is, to a large extent, interchangeable with sodium hydrosulfite in wood pulp bleaching applications.   There is also some interest in substituting sodium borohydride for both hydrosulfites in wood pulp bleaching, but sodium borohydride has yet to overcome a cost disadvantage.

In the case of vat dyeing, the outlook for sodium hydrosulfite is affected more by the development of new dyeing technologies than by direct substitution of other chemicals in the vat dyeing process (although here, again, sodium borohydride is a possible threat).   Some of these new techniques would substitute ammonium salts for sodium salts in the dye vat.   Others, such as solvent processing, would eliminate the use of salts altogether.   These developments are part of the continuing trend toward the predominance of synthetic fibers and synthetic/natural fiber blends in textile industry products.   The result of this trend can be seen in the accompanying synthetic dye production figures:

U.S. PRODUCTION OF SYNTHETIC DYES
(Thousands of Tons)

Year	Vat Dyes	Total
1965	28.8	103.6
1972	27.6	131.7

Total dye production grew at an annual compound rate of 3.5% from 1965 to 1972, while production of vat dyes declined at a rate of 0.6% per annum.

d.   Captive Requirements

Commerce Department data for the years 1968 through 1972 show merchant shipments to be identical with total shipments of sodium hydrosulfite, indicating the absence of captive consumption by these companies reporting production.   These figures, as well as data for total annual shipment value, are given in Table 92.

3.   Supply Characterization

a.   Manufacturing Routes

Sodium hydrosulfite is manufactured by several processes.   In one route, sulfur dioxide and metallic zinc are allowed to react in aqueous solution to form zinc hydrosulfite.   This product is then reacted further with caustic soda or soda ash to form sodium hydrosulfite and by-product zinc hydroxide or zinc carbonate.   Other routes include the reaction of zinc dust and sodium bisulfite; treatment of by-product sodium amalgam with sulfur dioxide; and the combination of sodium formate, caustic soda,

TABLE 92

SODIUM HYDROSULFITE SHIPMENTS AND SHIPMENT VALUE

Year	Total Shipments (Thousand Tons)	Merchant Shipments (Thousand Tons)	Value, f.o.b. Plant (Million Dollars)
1968	40.0	40.0	18.6
1969	38.6	38.6	19.7
1970	42.6	42.6	20.4
1971	43.3	43.3	19.3
1972	46.9	46.9	20.9

SOURCE: U.S. Department of Commerce.

and sulfur dioxide to form sodium hydrosulfite product along with numerous co-products.

Olin Corporation operates a small sodium hydrosulfite plant in Augusta, Georgia, which produces liquid product. The advantage of liquid sodium hydrosulfite, over the normal commercial flake form, is said to be reduced storage and handling costs.

b. Producers

In 1972 there were five producers of sodium hydrosulfite. Producers' identities, along with plant locations and capacities, are given in Table 93. One producer, Virginia Chemicals, Inc., accounts for nearly 55% of known U.S. capacity. If Royce Chemical Company's capacity is added to that of Virginia Chemical, the combination represents more than three-quarters of potential U.S. sodium hydrosulfite output. Not included in Table 93 are some large textile firms which do not report in-house production of some hydrosulfite.

To the extent that vertical integration exists among producers of sodium hydrosulfite, it is almost entirely in the direction of raw materials. For example, four out of the five producers are basic in sulfur dioxide and/or caustic soda, but none of the producers have significant vat dyeing or wood pulp bleaching operations. Royce Chemical Company specializes in textile chemicals and is perhaps the least integrated of the five producers.

c. Manufacturing Economics

Estimated manufacturing costs for sodium hydrosulfite are given in Table 94. These estimates assume a plant having 15,000 tons annual capacity and a fixed investment of $1.6 million.

4. Supply/Demand Balance

Although Rohm & Haas shut down 10,000 tons of annual sodium hydrosulfite capacity at Bristol, Pennsylvania, during 1972, other plant expansions and new facilities have kept capacity at a level where supply and demand have been fairly well balanced in recent years. In 1971, production was 90% of capacity (1971 capacity, including the aforementioned Rohm & Haas plant, totaled 46,000 tons), while in 1972, production was 88% of capacity (taken as 53,000 tons).

5. Prices

From 1963 to 1972 the list price of flake sodium hydrosulfite rose from $440 per ton to $610 per ton, representing an average annual increase of about 4%. Actual shipment value, on the other hand, has fluctuated widely from a low of $445.58 per ton in 1963, to a high of $510.36 average cost per ton in 1969. In 1971 and 1972, the average shipment value was back to the 1963 level of about $446 per ton. These actual shipment values

TABLE 93

SODIUM HYDROSULFITE PRODUCERS

Company	Location	Annual Capacity (Thousands of Tons)	(% of Total)
Cities Service Co., Inc. North American Chemicals and Metals Group Industrial Chemicals Div.	Copperhill, Tennessee	3	5.7
Diamond Shamrock Corp. Diamond Shamrock Chemical Co. Nopco Chemical Division	Carlstadt, New Jersey	6	11.3
	Augusta, Georgia	3	5.7
Olin Corp. Industrial Products and Services Division	East Rutherford, New Jersey	12	22.6
Royce Chemical Co.	Bucks, Alabama	15	28.3
Virginia Chemicals Inc.	Portsmouth, Virginia	14	26.4
	Leeds, S. Carolina	N.A.	N.A.
TOTAL		53	100.0

SOURCE: Published estimates.

TABLE 94

ESTIMATED COST OF MANUFACTURING SODIUM HYDROSULFITE

Physical Investment
Process		$1,200,000
Auxiliaries		400,000
Total		$1,600,000

Capacity   90,900 lb/SD, 15,000 Tons/Yr
Operating Factor   3 shifts/day, 330 SD/Yr

	Quantity/Ton	$/Unit	$/Ton
Variable Costs			
Raw Materials			
Zinc metal	816 lbs	0.19	155.04
Sulfur dioxide	1640 lbs	0.035	57.40
Sodium carbonate	1400 lbs	0.03	42.00
Sodium chloride	6500 lbs	0.00175	11.38
Utilities			
Power	158 Kwh	0.0137	2.16
Process Water	5.2 M gal	0.40	2.08
Cooling water	46 M gal	0.05	2.30
Natural Gas	13.2 MMBtu	0.597	7.88
Steam	7.4 M lbs	1.00	7.40
Ethanol	20 gal	0.50	10.00
Drums			60.00
Total Variable Costs			357.64
Semi-Variable Costs			
Operating Labor	3 men/shift	$4.31/m-h	7.56
Supervision	1 man	$15,000/yr	1.00
Maintenance	5% of Investment/Yr		5.34
Labor Overhead	60% of Labor & Supervision		5.12
Total Semi-Variable Costs			19.02
Fixed Costs			
Plant Overhead	40% of Labor & Supervision		3.42
Depreciation	11.1% of Investment/Yr		11.84
Taxes & Insurance	1.5% of Investment/Yr		1.60
Total Fixed Costs			16.86
Subtotal			393.52
By-Product Credit			
Zinc carbonate	1520 lbs	0.04	(60.80)
TOTAL COST OF MANUFACTURE			332.72

SOURCE: Contractor estimates.

were calculated from Department of Commerce data, and represent average plant prices. In Table 95, we have summarized these data for the period 1963 to 1972.

While the data needed to calculate average plant prices are not yet available beyond 1972, there are indications that sodium hydrosulfite list prices will reach $800 per ton in 1974. Unless unforeseen factors come into play, it is unlikely that producers will be able to sustain a proportionate increase in average plant prices.

T. SODIUM SILICOFLUORIDE

1. Summary

U.S. consumption of sodium silicofluoride totaled 64,000 tons in 1972. Of this total, 57,400 tons were supplied by domestic production, the remainder by imported material. Although U.S. output has shown a 4.3% overall increase during the ten-year period, 1963 to 1972, levels have remained essentially constant for the last three years. This is due principally to a stagnant, perhaps decreasing, demand for the silico-fluoride in its primary uses as a water fluoridation agent, and as a raw material for synthetic cryolite. Substitute materials are competitively available for both of these applications.

There are currently five active, domestic producers of sodium silico-fluoride. Ninety percent of the product is derived from three manufacturers-- Kaiser, Gardinier, and Olin. Kaiser's production is totally captive and is used for synthetic cryolite. Only 91% of the U.S. capacity for this silicofluoride was used in 1972. Current indicators suggest no substantial change in demand for the material in the near future.

2. Market Characterization

a. Market Size and Growth

Table 96 shows U.S. Department of Commerce statistics for sodium silicofluoride production, foreign trade, and apparent consumption for the years 1963 through 1972. Although the overall annual growth rate for U.S. production of this material was 4.3% during this time, little variation occurred in output during the last three years. Correspondingly, the annual increase in apparent U.S. consumption, averaged over the entire period, was 5.1%. However, since 1969, virtually no change in the 64,000 to 67,000 ton consumption figure has been observed. At approximately 10% of domestic production, imported sodium silicofluoride appears to have little impact on the overall U.S. market except to make up shortages when U.S. production is low.

b. Uses

Water fluoridation and the production of synthetic cryolite are the two largest, single uses for sodium silicofluoride. Other market areas provide a substantially smaller annual demand for this material.

192

TABLE 95

ACTUAL VERSUS LIST PRICES FOR SODIUM HYDROSULFITE

Year	Shipment Quantity (Thousand Tons)	Average Value ($ Millions)	Average Unit Value ($/Ton)	List Price ($/Ton)
1963	29.4	13.1	445.58	440
1964	31.7	14.2	447.95	480
1965	35.0	16.4	468.57	480
1966	39.7	19.1	481.11	500
1967	36.0	16.7	463.89	530
1968	40.0	18.6	465.00	530
1969	38.6	19.7	510.36	530
1970	42.6	20.4	478.87	550
1971	43.3	19.3	445.73	580
1972	46.9	20.9	446.02	610

SOURCES: U.S. Department of Commerce and Chemical Marketing Reporter.

TABLE 96

PRODUCTION, FOREIGN TRADE, AND APPARENT CONSUMPTION OF SODIUM SILICOFLUORIDE

(Thousands of Short Tons)

Year	Production	Imports	Exports	Apparent Consumption
1963	40.1	2.8	NA	42.9
1964	39.7	3.6	NA	43.3
1965	46.5	4.8	NA	51.3
1966	48.0	3.9	NA	51.9
1967	52.3	7.8	NA	60.1
1968	46.3	12.1	NA	58.4
1969	49.0	17.7	NA	66.7
1970	58.8	7.3	NA	66.1
1971	60.4	6.2	NA	66.6
1972	57.4	6.6	NA	64.0

SOURCE: U.S. Department of Commerce.

Recent Public Health Service data indicates that, in 1972, 59.2% of the U.S. population using public water supplies (estimated to be 160 million people) were using either controlled or naturally fluoridated water. Of this number, 80.8 million were using controlled fluoridation and approximately 40.4 million were using sodium silicofluoride as the fluoridating agent. This resulted in an estimated demand of 17,000 tons of material to achieve an average 1.0 ppm fluorine content in the water supplies.

Although the number of public water systems fluoridating supplies is continually increasing, sodium silicofluoride is enjoying less popularity in this application. Difficulty in handling, poor applicator reliability and lifetime, and (often) poor relative economics have prompted the use of substitute fluoride compounds, especially in the largest and the smallest water systems. Fluoridation equipment manufacturers have confirmed such a trend toward more easily metered liquids (fluosilicic acid) and solids with a more constant solubility (sodium fluoride, which has essentially a uniform 4% solubility and can therefore be metered on a volumetric basis rather than on a dry weight basis).

In primary aluminum production, cryolite (Na_3AlF_6) is used with aluminum fluoride as a molten electrolyte in the electrolytic reduction of alumina to aluminum metal. A large proportion of cryolite is now synthetic due to an acute shortage of the natural material. Kaiser Aluminum and Chemical Corporation is the only producer of synthetic cryolite using sodium silicofluoride as a starting material. The silicofluoride is manufactured from fluosilicic acid at Kaiser's plant in Mulberry, Florida, and shipped to Kaiser's plant in Chalmette, Louisiana for processing to cryolite. Other synthetic cryolite routes do not involve the manufacture of sodium silicofluoride. Kaiser's current cryolite capacity is 30,000 tons per year, which requires a minimum silicofluoride input of 26,800 tons per year.

This demand for cryolite, and therefore for sodium silicofluoride, is intimately tied in with primary aluminum production. The industry-wide operating factor for aluminum dropped from 95% of capacity in 1970 to 85% in 1971. Although this is expected to increase throughout the decade, no great increase in sodium silicofluoride usage is anticipated.

Other minor uses for sodium silicofluoride include:

(1) leather and wood preservatives;
(2) glue;
(3) opacification of vitreous enamel frits;
(4) opalescent glass;
(5) laundry sours;
(6) insecticides and rodenticides;
(7) coagulating agent for latex;
(8) extraction of beryllium from its ores; and
(9) manufacture of sodium fluoride.

Table 97 presents estimated quantities used in various applications.

c. Substitute Products

Water fluoridation may be accomplished by other fluoride-containing substances in place of sodium silicofluoride. Although sodium silicofluoride is the least costly (f.o.b. point of manufacture) on a per pound of available fluorine basis when compared to sodium fluoride and fluosilicic acid (agents most commonly used), shipping expenses and fluoridation equipment cost and operating expenses ultimately bring all three to nearly a competitive position. Fluosilicic acid, an acid in liquid form, provides a readily shipped, easily metered and controlled (on a volumetric basis) fluoridating agent. Larger communities have shown preference for the acid over other choices. Smaller communities have favored sodium fluoride due to its higher and constant 4% solubility level over most application temperatures. This allows controlled dissolution of the granular solid and subsequent volumetric metering. Sodium silicofluoride is typically metered into water systems as a dry powder or as a temperature-controlled solution. Table 98 provides a comparison of the three fluoridation products.

In addition to cryolite, aluminum fluoride is used as a molten electrolyte in the electrolytic reduction of alumina to aluminum metal. The two fluxes are to some degree interchangeable, depending upon operating practices and the sodium oxide content of the alumina used in the reduction plant. Moreover, synthetic cryolite may be manufactured directly from hydrofluoric acid without an intermediate production of sodium silicofluoride. Kaiser is the only cryolite producer following the silicofluoride route.

Potassium silicofluoride is a viable substitute for sodium silico-fluoride in production of vitreous enamels. The current laundry sour market has become oriented toward materials more voluble than sodium silicofluoride.

d. Captive Requirements

Kaiser's total production of sodium silicofluoride is used for production of synthetic cryolite. None of the material is put on the open market. However, Kaiser's current demand for its synthetic cryolite is only 18,000 tons per year; the remaining 12,000 to 14,000 tons is sold to other aluminum producers.

3. Supply Characterization

a. Manufacturing Routes

Sodium silicofluoride is a by-product of the fertilizer industry's wet process phosphoric acid production. Fluosilicic acid, the primary raw material for silicofluorides, is present as an impurity in the product phosphoric acid. Two primary schemes are in current use for producing silicofluoride. In the first, the recovered fluosilicic acid is reacted with sodium chloride in water. Sodium silicofluoride is collected as a precipitate, washed, dried, and packaged. In the second, fluosilicic acid is not recovered as a separate stream, but rather, remains mixed in an impure phosphoric acid stream. Soda ash is mixed with the acid to form

TABLE 97

End Use Pattern for Sodium Silicofluoride

(Thousands of Tons)

	1966	1972
Water Fluoridation	12.6	17.0
Synthetic Cryolite	N.A.	30.0
Glass	2.6	2.7
Metallurgy of Beryllium	2.3	2.5
Vitreous Enamel Frits	1.5	1.5
Other:	N.A.	10.3

      preservative
      glue
      laundry sour
      insecticide
      latex
      intermediate chemical
      (production of sodium fluoride)

	1966	1972
TOTALS	51.9	64.0

Source: Contractor Estimates

TABLE 98

Primary Water Fluoridation Material

	Substance		
	Sodium Fluoride (NaF)	Sodium Silicofluoride (Na_2SiF_6)	Fluosilicic Acid (H_2SiF_6)
Form	Granular Powder or Crystal	Fine Powder or Crystal	Liquid
Commercial Purity, %	90-98%	98-99%	22-30%
Fluoride Ion, % (100% Pure Material)	42.3%	60.7%	79.2%
Lb required per 10^6 gallons for 1.0 ppm F at (indicated purity)	18.8 (98%)	14.0 (98.5%)	35.2 (30%)
Solubility, g/100 g H_2O @ 25°C	4.05	0.762	infinite
Cost, $/Lb Total (F.O.B. point of manufacture)	0.180 - 0.250	0.08 - 0.10	0.025 - 0.15
Cost, $/Lb Available F (F.O.B. point of manufacture)	0.410 - 0.570	0.130 - 0.170	0.140 - 0.630

Source: Fluoridation Engineering Manual, Published by EPA, 1972.

and precipitate the sodium silicofluoride. Again, the salt is separated, washed, and dried for packaging. These two process routes account for all of the annual domestic production of sodium silicofluoride.

b. Producers

There are currently five active producers (seven plants) of sodium silicofluoride in the United States. The largest is Kaiser Aluminum and Chemicals Corp., followed by Gardinier and Olin. These three account for nearly 90% of the annual domestic production. Table   shows each company with location and estimated capacity.

Olin Corporation has reduced its capacity more than 50% by shutting down its Pasadena, Texas, facility on April 1, 1974. Kerr-McGee has also ceased sodium silicofluoride production at its Baltimore, Maryland, plant and therefore is no longer a producer.

Kaiser, by far the largest producer of sodium silicofluoride, maintains captive use of all of its product for the synthesis of cryolite.

c. Manufacturing Economics

Estimated manufacturing costs for sodium silicofluoride are given in Table 100.

4. Supply/Demand Balance

a. Capacity Utilization

U.S. sodium silicofluoride capacity appears to be in excess of actual production. 1972 data indicate only 91% of the estimated 62,850 ton capacity to have been utilized.

Indications are that demand for sodium silicofluoride will not change substantially in the near future. Kaiser has stated that demand for synthetic cryolite is slipping; the popularity once enjoyed by silico-fluoride in water fluoridation is also waning. Olin's and Kerr-McGee's plant shutdowns lend credence to this trend.

5. Prices

Price data were compiled for both domestic and imported sodium silicofluoride. Table 101 shows the gradual price increase during the 1963 to 1972 period. The "actual" prices are as calculated from Department of Commerce data for total shipments and represent industry average plant prices. The list prices were taken directly from the weekly data compiled by the Chemical Marketing Reporter and represents open market prices. The list prices for domestic sodium silicofluoride are substantially higher than plant unit values. For comparison, Table 102 presents prices of imported sodium silicofluoride. Although unit values (dollars per ton) are lower than domestic material, added import duties as well as protective controls by U.S. distributors bring imported sodium silicofluoride into

TABLE 99

SODIUM SILICOFLUORIDE PRODUCERS

Company	Location	Estimated Capacity (short tons/year)
Columbia Nitrogen Corporation	Moultrie, Georgia	250
Gardinier, Inc. U.S. Phosphoric Products (Formerly owned by Cities Service)	Tampa, Florida	12,000
Kaiser Aluminum & Chemical Corporation Kaiser Chemicals Division	Mulberry, Florida	30,000
Kerr-McGee Corporation Kerr-McGee Chemical Corporation (Subsid.)	Baltimore, Maryland	N.A. no longer produce
Olin Corporation Agricultural Chemicals Division (Shut down as of April 1, 1974) Industrial Products & Services Division	Pasadena, Texas Joliet, Illinois	8,600 no longer produce
The Williams Companies Agrico Chemical Company (Subsid.)	Buffalo, New York Pensacola, Florida	2,000 2,000
TOTAL		54,250

Sources: 1974 Directory of Chemical Producers (SRI); Chemical Week Buyers Guide, October 31, 1973; Chemical Sources--U.S.A., 1974; Chemical Economics Handbook (SRI), March 1973; Thomas Register, 1973 (American Manufacturers); Contractor Private Communications.

200

TABLE 100

ESTIMATED COST OF MANUFACTURING SODIUM SILICOFLUORIDE

Physical Investment
    Process $2,200,000
    Auxiliaries   600,000
    Total $2,800,000
Capacity   121,000 lb/SD, 20,000 tons/yr
Operating Factor   3 shifts/day, 330 SD/yr

	Quantity/Ton	$/Unit	$/Ton
Variable Costs			
Raw Materials			
Sodium chloride	1560 lbs	0.00175	2.72
Fluosilicic acid	1920 lbs	0.0216	41.48
Lime	1100 lbs	0.0085	9.36
Utilities			
Power	90 kwh	0.0137	1.10
Water	6 M gal	0.40	2.40
Natural gas	4 MMBtu	0.597	2.38
Total Variable Costs			59.44
Semi-Variable Costs			
Operating Labor	2 men/shift	$4.31/m-h	3.78
Supervision	1 man	$15,000/yr	0.76
Maintenance	5% of Investment/yr		7.00
Labor Overhead	60% of Labor & Supervision		2.72
Total Semi-Variable Costs			14.26
Fixed Costs			
Plant Overhead	40% of Labor & Supervision		1.82
Depreciation	11.1% of Investment/yr		15.54
Taxes & Insurance	1.5% of Investment/yr		2.10
Total Fixed Costs			19.46
TOTAL COST OF MANUFACTURE			93.16

SOURCE: Contractor estimates.

TABLE 101

ACTUAL VERSUS LIST PRICES FOR DOMESTIC SODIUM SILICOFLUORIDE

Total Product Shipment
(Including Interplant Transfers)

Year	Shipment Quantity (Thousands of Short Tons)	Value ($ Millions)	Unit Value ($/Ton)	List Price* ($/Ton)
1963	35.2	4.01	113.91	140
1964	37.7	4.62	122.62	150
1965	41.0	5.39	131.60	150
1966	45.6	6.06	132.86	150
1967	48.8	6.77	138.60	160
1968	44.9	6.25	139.05	160
1969	47.0	6.34	134.96	160
1970	56.1	7.43	132.48	160
1971	57.4	7.90	137.63	180
1972	54.2	6.33	116.67	180

*where a range of prices was listed for a given year, the lowest value was used for calculations in this table

SOURCE: U.S. Department of Commerce and Chemical Marketing Reporter.

TABLE 102

ACTUAL PRICE FOR IMPORTED SODIUM SILICOFLUORIDE

Year	Quantity (Thousands of Short Tons)	Value ($ Millions)	Unit Value[*] ($/Ton)	Import Duty Addition (As % Added To Value)
1963	2.8	0.25	87.96	NA
1964	3.6	0.36	98.20	NA
1965	4.8	0.43	88.89	NA
1966	3.9	0.34	87.75	NA
1967	7.8	0.69	88.83	NA
1968	12.1	0.95	78.73	NA
1969	17.7	1.36	76.78	18.4
1970	7.3	0.65	88.94	10.7
1971	6.2	0.60	96.10	7.7
1972	6.6	0.67	101.85	5.9

[*] unit value was calculated without adding U.S. Import Duty to the actual value

SOURCE: U.S. Department of Commerce.

a competitive position. Imports primarily fill deficiencies in U.S. production.

U. SODIUM THIOSULFATE

1. Summary

In 1972, domestic consumption of sodium thiosulfate was 23,962 tons, down 4.7% from 1971. Export and import quantities are believed to be negligible. Demand for sodium thiosulfate has declined steadily at 2 to 3% per year for the past ten years. This decline is largely due to sodium thiosulfate's replacement by ammonium thiosulfate in photographic applications, sodium hypo's predominant use. Other uses are in leather tanning and miscellaneous chemical applications. Only 2 to 3% of sodium thiosulfate output is captively consumed.

There are currently three producers of sodium thiosulfate. Allied Chemical is the major supplier, with over 80% of industry capacity. Declining use has resulted in substantial overcapacity, although this situation was relieved somewhat by du Pont's withdrawal from sodium thiosulfate manufacture last year. In 1972, the industry operating rate was approximately 50%.

2. Market Characterization

a. Market Size and Growth

Total 1972 shipments for sodium thiosulfate were 23,962 tons, of which all but 605 tons were commercial (i.e., for merchant consumption). Table 103 summarizes the recent history of shipments, and indicates that demand for sodium thiosulfate has been decreasing at almost 3% per year since the early 1960's. Export/import data are not available, but amounts are believed to be negligible. Projections for future demand indicate further decline at 2 to 3% per year.

b. Uses

Table 104 details the current uses for sodium thiosulfate. The predominant use is in photography, where sodium thiosulfate (hypo) is used as a fixing agent in film negative development. Photographic use amounted to about 21,500 tons in 1972. Hypo solution is used to dissolve unexposed silver, thus preventing further film development. This fixing process is required in all photographic products which utilize silver halides as the light sensitive ingredient. These products include amateur and professional films (color and black-and-white), X-ray films, microfilm, and numerous other items. Sodium hypo's use in photographic applications has been declining steadily due to the emergence of ammonium thiosulfate as a superior fixative. This replacement has been particularly acute in applications requiring high-speed fixing action, such as in X-ray film processing.

TABLE 103

SODIUM THIOSULFATE
PRODUCTION, IMPORTS, EXPORTS, APPARENT CONSUMPTION

(Thousands of Tons)

Year	Production	Imports	Exports	Apparent Consumption
1968	30.5	NA	NA	30.5
1969	29.8	NA	NA	29.8
1970	25.5	NA	NA	25.5
1971	25.1	NA	NA	25.1
1972	21.6	NA	NA	21.6

SOURCE: U.S. Department of Commerce.

TABLE 104

SODIUM THIOSULFATE USE PATTERN

Application	Consumption	
	Thousand Tons	(% of total)
Photography	21.5	90
Leather Tanning	1.6	7
Miscellaneous	0.3	3
	23.4	100

SOURCE: Published Sources.

Other uses of sodium thiosulfate are relatively minor, but the largest is as a reducing agent in chrome tanning of leather. In this applications, sodium thiosulfate is used to treat leather following a second dichromate soaking bath. Consumption in this application is static, however, since the two-bath chrome process has been largely supplanted by the single-bath process which does not require sodium thiosulfate. Tanning use was about 1,600 tons in 1972. Miscellaneous uses were in wood pulp bleaching, fabric dyeing, and chemicals manufacture.

c. Substitute Products

Sodium thiosulfate's market erosion is almost entirely due to its replacement in photographic applications by ammonium thiosulfate (ammonium hypo). Ammonium thiosulfate is considerably more soluble than sodium thiosulfate, and ammonium hypo solutions can therefore be prepared to much higher concentrates over older, dry sodium hypo which must be mixed by the user. Ammonium hypo provides additional processing benefits to the photographic processor through faster fixing rates, longer shelf life, and more easily handled wastes. As a result, ammonium hypo's demand has increased in excess of 15% per year during the 1960's and has replaced sodium hypo in many applications.

In other applications substitute products are similarly common. In leather tanning, for example, the one-bath chrome process uses glucose as the reducing agent instead of sodium thiosulfate. In miscellaneous chemical and pulp applications, sodium sulfite, sodium bisulfite, and sulfur dioxide can be used in place of sodium thiosulfate.

d. Captive Requirements

Captive requirements are minimal as indicated in Table 105. In 1972, only 605 tons, or about 3%, was consumed captively. This low captive consumption is due to sodium thiosulfate's predominant use in photography, where it is distributed widely to many retail end uses.

3. Supply Characterization

a. Manufacturing Routes

Sodium thiosulfate can be manufactured from a variety of processes which utilize sodium salt liquors and either elemental sulfur or sulfur dioxide. The specific process is usually a function of what liquor is available from other processes in the production complex. Reactions for two such commercial processes are as follows:
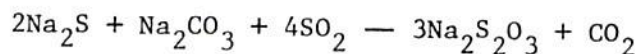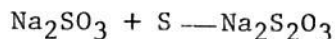
(1) Sulfide Liquor

$$2Na_2S + Na_2CO_3 + 4SO_2 \longrightarrow 3Na_2S_2O_3 + CO_2$$

207

TABLE 105

SODIUM THIOSULFATE CAPTIVE CONSUMPTION

Year	Total Shipments (Thousand Tons)	Commercial Shipments (Thousand Tons)	(% of Total)
1966	29.1	N.A.	N.A.
1968	29.3	N.A.	N.A.
1970	25.2	N.A.	N.A.
1971	25.2	24.4	97.1
1972	24.0	23.4	97.5

SOURCE: U.S. Department of Commerce.

(2) Sulfite Liquor

$$Na_2SO_3 + S \longrightarrow Na_2S_2O_3$$

Regardless of the exact raw materials, the recovery and purification system is a relatively straightforward filtration-evaporation-crystallization sequence. The pentahydrate form product can be obtained after initial crystallization and drying. Further processing, involving remelting and recrystallization, yields the anhydrous product.

b. Producers

Presently three companies are producing sodium thiosulfate in five separate facilities. As shown in Table 106, Allied Chemical controls nearly 80% of known capacity and is the predominant factor in the industry. All plants are situated as a part of a larger chemical complex, primarily due to the need for sodium salt liquor raw material. Du Pont withdrew from sodium thiosulfate production at its Linden, New Jersey, plant last year, and now produces ammonium thiosulfate at the same location.

c. Manufacturing Economics

Estimated manufacturing costs for sodium thiosulfate are given in Table 107.

4. Supply/Demand Balance

Capacity utilization has been steadily decreasing in recent years. Based on the then existent industry capacity of 42,000 tons, 1971 and 1972 production amounted to 60% and 51% of total capacity, respectively. With the closing of du Pont's plant, utilization has risen back to the 70 to 80% range. This substantial supply excess is largely due to the continuing replacement of sodium thiosulfate by ammonium thiosulfate.

5. Prices

Table 108 summarizes price data for sodium thiosulfate. Unit value data were derived from U.S. Department of Commerce figures. Except where noted, unit values are for total shipments which very closely equal commercial shipments since interplant shipments are quite small.

Despite decreases in shipments, prices have generally moved higher in recent years. Industry sources attribute this increase to improved product quality and a trend toward anhydrous product.

TABLE 106

SODIUM THIOSULFATE PRODUCERS

Company	Location	Capacity (Thousand Tons)	(% of Total)
Allied Chemical	Chicago, Ill.	7	24
	El Segundo, Cal.	5	17
	North Claymont, Del.	10	35
Ferro	Baton Rouge, La.	2	7
Stauffer Chemical	South Gate, Cal.	5	17
Total		29	100

SOURCE: Published sources.

TABLE 107

ESTIMATED COST OF MANUFACTURING SODIUM THIOSULFATE

Capacity	10,000 T/yr	
Stream Factor	8,000 hr/yr	
Plant Investment		
Process	$600,000	
Auxiliaries	150,000	
Total	$750,000	

Variable Costs	Quantity/Ton	$/Unit	$/Ton
Raw Materials			
Sodium bisulfite	0.32 T	80	25.60
Sodium sulfite	0.37 T	22	8.14
Soda Ash	0.32 T	42	13.40
Sulfur	0.29 T	23.5	6.80
Utilities			
Steam	15 M lb	1.00	15.00
Power	16 kwh	0.0137	0.22
Water	61 M gal	0.05	3.05
Total Variable Costs			72.21
Semi-Variable Costs			
Operating Labor	2 men/shift	$4.31/m-h	6.90
Supervision	1 supervisor	$15,000/yr	1.50
Maintenance	5% of Investment/yr		3.75
Labor Overhead	60% of Labor & Supervision		5.05
Total Semi-Variable Costs			17.20
Fixed Costs			
Plant Overhead	40% of Labor & Supervision		3.35
Depreciation	11.1% of Depreciable Investment/yr		4.80
Taxes & Insurance	1.5% of Investment/yr		1.12
Total Fixed Costs			9.27
TOTAL COST OF MANUFACTURE			98.68

SOURCE: Contractor estimates.

TABLE 108

SODIUM THIOSULFATE PRICE HISTORY

Year	Shipment Quantity (Thousand Tons)	Value ($ Millions)	Unit Value ($/Ton)	List Price ($/Ton) Pentahydrate	Anhydrous
1963	NA	--	--	99.0	155.0
1964	NA	--	--	99.0	155.0
1965	NA	--	--	99.0	155.0
1966	NA	--	--	99.0	161.0
1967*	NA	--	--	99.0	161.0
1968	29.3	2.5	85.5	141.0	183.0
1969	29.1	2.7	91.8	141.0	183.0
1970	25.2	2.4	95.3	141.0	183.0
1971**	24.4	2.6	104.6	154.0	203.0
1972**	23.4	2.6	110.8	161.0	212.0

* Department of Commerce data not available 1963-1967.

** Commercial shipments only.

SOURCES: U.S. Department of Commerce, Chemical Marketing Reporter.

V. SULFUR DIOXIDE

1. Summary

The merchant market for liquid sulfur dioxide in 1972 was 144,000 tons of which 100,000 tons were produced in the United States. Consumption has been relatively static in recent years, growing at an annual compounded rate of only 2%.

Major applications for liquid sulfur dioxide are in the pulp and paper industry, the manufacture of industrial soya proteins, and the bleaching of agricultural food products. In these, only the food industry applications present a major problem of substitution should liquid sulfur dioxide production be curtailed.

U.S. production capacity has been recently expanded by the installation of processes for removal of sulfur from the stack gases of sulfide ore smelting plants and converting the sulfur to liquid sulfur dioxide. Such capacity expansion has changed the U.S. supply/demand balance from one for which capacity was less than demand, and major imports from Canada were needed to meet demand, to one where U.S. capacity is a third larger than demand. Furthermore, for new U.S. capacity based on production from sulfide ore smelting stack gases, manufacturing economics are not the critical factor relative to the viability of the operation and new production tends to be resistant to shutdown from increased cost of production.

2. Market Characterization

a. Market Size and Growth

Department of Commerce data for liquid sulfur dioxide produced for sale, foreign trade and apparent consumption for the period 1963 to 1972 are presented in Table 109. (It is important to note that the U.S. Department of Commerce production figures in Table 109 are designated as produced for sale and exclude, therefore, most captive production not designated as produced for sale.) In the first half of this period (1963 to 1968), U.S. production for sale increased at an average annual compound rate of approximately 11%, but then declined in the second half of the period (1968 to 1972) at an average rate of 5% per year. Peak production for sale in the United States was achieved in 1969.

The decline in production for sale of liquid sulfur dioxide in recent years is not an indication of declining merchant consumption, however, because increasing imports of liquid sulfur dioxide from Canada has resulted in an expansion in U.S. consumption. Apparent consumption has increased despite declining production (1968 to 1972) at an average annual rate of approximately 2%. Imports quadrupled in that period.

213

TABLE 109

PRODUCTION, FOREIGN TRADE, AND
APPARENT CONSUMPTION OF SULFUR DIOXIDE

(Thousands of Tons)

Year	Production	Imports	Exports	Apparent Consumption
1963	73	NA	NA	NA
1964	82	NA	NA	NA
1965	101	NA	NA	NA
1966	106	NA	NA	NA
1967	108	NA	NA	NA
1968	124	10	NA	134
1969	128	9	NA	137
1970	109	26	NA	135
1971	93	39	NA	132
1972	100	44	NA	144

SOURCE: U. S. Department of Commerce.

214

b. Uses

For many applications of sulfur dioxide in either chemical manu-
facture or the production of sulfite pulp, the sulfur dioxide is produced
on site by burning sulfur. Such production is outside the scope of this
analysis. The applications for merchant liquid sulfur dioxide thus tend to
be those where the relatively small volume used, the restrictions of the
process, or the handling and storage advantages of liquid sulfur dioxide,
promote such use.

Two of the significant merchant applications are found in the pulp
and paper industry where liquid sulfur dioxide is purchased even though it
is not generally used to produce sulfite pulp. One of these is the
production of chlorine dioxide for bleaching of pulp. In manufacturing
chlorine dioxide, sulfur dioxide may be used as the reducing agent.
Another use of sulfur dioxide is as an "antichlor" to terminate a conventional
bleaching operation in which chlorine, hypochlorite or chlorine dioxide is
the bleach. Such specialized uses in the pulp and paper industry probably
account for 25 to 35% of the U.S. merchant consumption of liquid sulfur
dioxide.

Another major use of liquid sulfur dioxide is in the manufacture
of industrial soya proteins, particularly those grades used as adhesives
or binders. The sulfur dioxide acts both to precipitate the protein and
control color.

Sulfur dioxide has numerous applications in the processing of
agricultural products as a bleach or fumigant. For example, it may be
used as a bleaching agent in the refining of beet sugar. Fresh fruits
subject to rapid spoilage may be fumigated with sulfur dioxide before
shipment or storage.

In the processing of potatoes or apples an environment of sulfur
dioxide inhibits the enzymatic deterioration of color, i.e., the browning
of the slices. Sulfur dioxide is also used in the manufacture of wine
to control the fermentation.

c. Substitute Products

In the paper pulp applications, liquid sulfur dioxide is not
crucial to the bleaching process, either for production of chlorine dioxide
or as an antichlor. In the manufacture of chlorine dioxide, either
methanol or sodium chloride under strongly acidic conditions may be used
and sulfur dioxide is not required. In fact, with the process using sodium
chloride, if the by-product chlorine and salt cake are usable on site,
sodium chloride reduction is more economic. Reducing agents other than
sulfur dioxide, e.g., sodium bisulfite, may be used as an antichlor.

It is in the processing of agricultural products where substitu-
tion of purchased liquid sulfur dioxide would create the most dislocation.

For years the food industry has been selling sulfur dioxide substitutes which would be equally cost effective but without the tendency to alter flavor which is characteristic of sulfur dioxide. The trend has been to use the minimum necessary to inhibit spoilage without generating off taste. However, substitution of other products for sulfur dioxide would be generally difficult because of the multiplicity of small applications, the food product safety requirements, and the absence of adverse residues from sulfur dioxide treatment.

d. Captive Requirements

Most captive production of sulfur dioxide is on site and manufactured by burning of sulfur. For example, most of the sulfite pulp is manufactured using captive sulfur dioxide rather than purchased material. This is also the case with most chemicals manufactured from sulfur dioxide such as zinc hydrosulfite and sodium hydrosulfite. The liquid sulfur dioxide manufactured for merchant sale thus represents only a minor portion of the total U.S. requirements for sulfur dioxide. It is this market for merchant sale of liquid sulfur dioxide with which we are concerned and by definition little of it is for captive use.

3. Supply Characterization

a. Manufacturing Routes

Sulfur dioxide, when produced for sale, is either manufactured by the burning of sulfur or the smelting of sulfide ores.

The essential process steps when sulfur is burned are the absorption of the resultant sulfur dioxide in water, the drying of the sulfur dioxide in concentrated sulfuric acid, and the liquefaction to sulfur dioxide for shipment in cylinders or tank cars under two to three atmospheres pressure. Where sulfur is burned to produce sulfur dioxide for subsequent on site chemical reaction, e.g., the manufacture of sulfuric acid, liquefied sulfur dioxide may be a co-product.

Where sulfur dioxide is obtained from the smelting of sulfide ores, it is an essential pollution control element in the process. Sulfur dioxide and sulfuric acid may be co-products of the removal of sulfur from the stack gases resulting from smelting operations. The operations are much more complex than producing sulfur dioxide from the direct burning of sulfur because the sulfur dioxide stream must be concentrated and contaminants, especially particulate matter, removed.

b. Producers

There are six primary producers of liquid sulfur dioxide operating seven plants as follows:

Producer	Location	Annual Capacity (Thousand of Tons)
American Smelting and Refining Co.	Tacoma, Washington	66
Cities Service Co.	Copperhill, Tenn.	50
Virginia Chemicals, Inc.	West Norfolk, Va.	40
Essex Chemical Corp.	Newark, N.J.	15
Ansul Co.	Marinette, Wis.	15
Stauffer Chemical Co.	Baton Rouge, La.	13
Stauffer Chemical Co.	Hammond, Ind.	10
	Total	209

Of the above companies, Stauffer Chemical Company and Essex Chemical Corporation are primary producers of sulfuric acid as well as sulfur dioxide. Virginia Chemicals, Inc., is a primary producer of zinc and sodium hydrosulfites which represent a major captive market for sulfur dioxide. American Smelting and Refining Company and Cities Service Company are producers of metals from sulfide ores and obtain sulfur dioxide as an essential pollution control mechanism. Ansul Company originally produced sulfur dioxide as a refrigerant and continues to be a merchant producer of the liquid form.

c. Manufacturing Economics

Estimated manufacturing costs for direct production of liquid sulfur dioxide by burning of sulfur are shown in Table 110. Raw material costs are those to be effective May 1, 1974. The cost estimates are based on a plant with an annual capacity of 40,000 short tons and a fixed investment of $2.5 million. The plant is assumed to be part of a larger chemical complex but not one for which sulfuric acid is a primary product.

This manufacturing cost of $60 per ton compares unfavorably with a $55 per ton unit value provided by Commerce Department data for 1972. However, raw material costs, which represent about half of the manufacturing cost indicated, were about 30% less in 1972.

Furthermore, the manufacturing costs indicated for direct process manufacture, are probably quite different from the cost of manufacturing sulfur dioxide from recovered smelter stack gases. In the latter case where there is a primary necessity to remove sulfur as an air pollutant, production is not dependent upon the profitability of the operation.

4. Supply/Demand Balance

Prior to recent additions of sulfur dioxide capacity by recovery from smelter operations, the estimated U.S. capacity for liquid material manufactured for sale was 125,000 tons. Thus, in 1972 when apparent consumption was 144,000 tons there was opportunity for imports from Canada. The current U.S. capacity of over 200,000 tons is in excess of U.S. demand.

TABLE 110

ESTIMATED MANUFACTURING COST, SULFUR DIOXIDE

Plant Capacity: 40,000 Short Tons/Year

Fixed Investment: $2,500,000

Item	Units	$/Unit	Units/Ton	$/Ton
Raw Materials				
Sulfur	Pounds	.018	1,080	19.44
Sulfuric Acid (98%)	Pounds	.021	600	12.60
Water Make-up	1,000 gal.	.10	2	0.20
Utilities				
Power	Kwh	.01	15	.15
Steam	Pounds	.002	6,800	13.60
Direct Labor				
Supervisors				.40
Operators				2.20
Overhead	(100% direct labor)			2.60
Maintenance	(2 1/2% of investment/year)			1.56
Maintenance Supplies	(3% investment/year)			1.88
Depreciation	(7% investment/year)			4.38
Taxes and Insurance	(1 1/2% investment/year)			.94
			TOTAL	59.95

SOURCE: Contractor estimates.

218

5. Prices

In Table 111 we have compared list tank car prices versus actual unit prices calculated from Commerce Department data for total shipments. The Commerce Department data also include shipments in cylinders for which the list price is higher than for shipment by tank car. It is interesting to note that in 1967 to 1968 the actual prices derived from Commerce Department data correspond almost exactly with the list prices.

W. ZINC OXIDE

1. Summary

According to U.S. Department of Commerce data, production of zinc oxide was about 240,000 tons in 1972. Foreign trade was modest but higher than in previous years with 1972 imports at 19,400 tons and exports at 6,000 tons. Based on historic data, consumption has been growing at an average compound rate of 2.5% a year between 1963 and 1972.

Zinc oxide has a variety of applications, the most important one being the vulcanization of rubber which takes over 50% of total production. Other important applications are in paint, electrographic copying and chemicals. In general, there are no direct substitutes for zinc oxide in these applications. A very small volume of total production is used captively and almost entirely in paint formulation.

There are currently five major producers of zinc oxide plus a number of small producers which in the aggregate represent only about 10% of total capacity. Zinc oxide is produced primarily by metal companies integrated forward to zinc oxide production. New zinc oxide capacity has not been built recently. This fact, coupled with the closedown of several primary zinc plants which were also producing zinc oxide, has resulted in current supply shortages. In fact, demand currently exceeds supply. New capacity expected on-stream during 1974 may ease the shortage and create a more balanced supply/demand situation.

2. Market Characterization

a. Market Size and Growth

Department of Interior and Department of Commerce data for zinc oxide production, foreign trade and apparent consumption for the period 1963 to 1972 are shown in Table 112. Production of lead free zinc oxide (98% minimum) which represents about 98% of total production has increased at an average annual compound rate of approximately 4.5% during this time span. Production of leaded zinc oxide (5 to 7% basic lead sulfate) has declined at an average annual compound rate of approximately 9%. Production of leaded zinc oxide was discontinued during 1972 and total produced volume for that year is believed to be very low. Thus, total zinc oxide production

TABLE 111

ACTUAL VERSUS LIST PRICES FOR SULFUR DIOXIDE

Year	Unit Value* ($ Ton)	List Price** ($ Ton)
1963	66.65	90
1964	64.25	90
1965	56.90	65
1966	58.86	65
1967	70.43	69
1968	70.70	69
1969	67.90	75
1970	64.73	75
1971	59.48	75
1972	55.65	75

* U. S. Department of Commerce

** Chemical Marketing Reporter - tanks f.o.b. works

TABLE 112

PRODUCTION, FOREIGN TRADE, AND APPARENT CONSUMPTION
OF ZINC OXIDE

(Thousands of Short Tons)

Year	Production			Imports	Exports	Apparent[1] Consumption
	Lead-Free	Leaded	Total			
1963	157.4	15.1	173.4	14.0	3.0	184.4
1964	163.3	12.2	175.5	8.7	2.4	181.8
1965	187.8	12.6	200.4	11.6	2.7	209.3
1966	202.8	10.7	213.5	14.5	3.6	234.4
1967	187.2	9.7	196.9	13.8	3.4	207.3
1968	210.0	11.1	221.1	15.6	3.6	233.1
1969	220.4	4.9	225.3	14.6	3.8	236.1
1970	223.8	5.2	229.0	12.1	6.3	234.8
1971	215.0	5.3	220.3	13.1	6.7	226.7
1972	238.4	NA	NA	19.4	6.2	251.6

SOURCE: Mineral Industry Survey, USDI Bureau of Mines
         U.S. Department of Commerce, Bureau of the Census
         Manual of Current Indicators

Notes: [1] - Does not consider total stocks
        NA - Not available

for that year should be about 240,000 tons, only slightly above that for lead-free zinc oxide. This would represent, according to USDI data, an average compound growth rate of 2.5% from 1963 to 1972.

Import volume has fluctuated yearly reaching its maximum value of 19,400 tons in 1972, reflecting the beginning of a supply shortage. The average import volume, however, has been about 14,000 tons a year, approximately 6% of total production. Exports, although small, about 3% of production in 1971, have increased at an annual compound rate of 6%. Imports have always been higher than exports.

If a small production volume for leaded zinc oxide is taken into consideration, apparent consumption in 1972 was about 253,000 tons. The annual compound apparent consumption growth rate for the 1963 to 1972 period is about 2.5%, i.e., the same as production.

b. Uses

As shown in Table 113 zinc oxide has a number of different applications. Consumption by the rubber industry accounts for over 50% of total production and has been growing at about 3% a year. The principal application here is the activation of the organic accelerators used to shorten the time of vulcanization. It is also used as the actual accelerator for vulcanizing some specialty rubbers. Zinc oxide is also used as a reinforcing pigment where high resilience, heat resistance and heat conductivity are the most important properties of the elastomer product.

Its second major application is in paints; about 13% of total production. It is used primarily in exterior oil-based house paints where it is valuable for its mildew resistance, extreme whiteness and its ability to improve the drying and hardening characteristics of paint films by reacting with the drying oils present.

Consumption of lead-free zinc oxide in paint has remained rather stable primarily because of some technical difficulties in formulation concerning the incompatibility of zinc oxide with some of the oil bases used. The paint industry has overcome this difficulty which should increase future zinc oxide consumption. In addition, zinc oxide properties make it a desirable substitute for lead-base paints from which the industry is moving away. Therefore, consumption of zinc oxide by the paint industry is expected to show a more rapid growth trend in the future.

Consumption of zinc oxide in electrographic copying increased at a very fast rate of 30 to 40% a year from 1966 to 1969 and since then consumption has begun to level-off to less than 10% annual growth at present. Overall the average growth rate for the 1966 to 1971 period is about 12% a year. The semiconductivity and photoconductivity of zinc oxide are used in electrostatic reproduction processes. The consumption growth rate has been leveling-off primarily because of technical developments in reproduction process that eliminates the need for paper coating.

TABLE 113

U.S. CONSUMPTION OF ZINC OXIDE BY INDUSTRY

(Thousands of Short Tons)

Year	Agriculture	Ceramics	Chemicals	Elastomers	Paints			Photo-Copying	Other	Total
					Lead-Free	Leaded	Total			
1966	1.6	12.1	13.7	104.9	27.1	10.5	37.6	11.4	24.0	205.2
1967	5.0	9.8	17.5	94.4	24.5	8.6	33.1	14.0	17.9	191.8
1968	5.0	10.2	22.8	111.8	25.9	6.4	32.3	21.6	18.1	221.8
1969	4.0	9.5	22.8	116.0	25.2	4.9	30.1	27.6	16.8	226.7
1970	2.2	9.0	19.4	114.0	21.9	5.2	27.1	31.9	19.1	220.2
1971	1.6	8.1	18.9	124.5	25.0	---	25.0*	34.5*	14.9*	227.5*

Consumption and Growth Rate by Industry

	Percentage of Thousand Short Tons - 1971	Average Annual Growth Rate 1966-1971
Agriculture	1.8	- 0.0
Ceramics	4.2	- 8.0
Chemicals	10.0	+ 6.5 1/
Elastomers	51.2	+ 3.0
Paints	13.3	- 8.0
Photocopying	12.2	+25.0
Other	7.3	- 9.0
Total	100.0	2.0

SOURCE: Minerals Yearbook, U.S. Department of Interior, Bureau of Mines

Notes: *Does not include leaded zinc oxide; data withheld to avoid disclosing individual company
1/ From 1969 to 1971 average growth rate declined at about 10% a year

Other applications for zinc oxide include: agriculture, where it is used as a plant nutrient and animal feed supplement; ceramics, where it enhances color and increases brilliance; chemicals, primarily zinc soaps; textiles; catalysts; floor tiles and linoleum. Table 113 shows the relative importance of each end use to total consumption and their growth pattern for the period 1966 to 1971.

c. Substitute Products

Zinc oxide does not have any significant substitute products in its rubber and paint applications. In electrographic copying major competition is from alternative photocopying systems rather than competitive products. In the chemical area, its fourth largest segment, consumption has been declining, not necessarily because of substitute products, but as a result of recycling systems.

d. Captive Requirements

Commerce Department data for captive and merchant shipments of zinc oxide are not available. We believe, however, that captive outlets represent 2 to 4% of production and are primarily in paint.

3. Supply Characterization

a. Manufacturing Routes

Over 90% of zinc oxide manufacturing is by the dry process based on thermal oxidation of zinc. The remainder is by wet process using as raw material crude zinc oxide recovered from lead smelters. Both processes are markedly different with respect to generation of water-borne wastes.

There are two variations to the dry process, the American (direct) and the French (indirect), with the former accounting for about two-thirds of total production. Both procesees maybe used at the same plant. At one manufacturing plant using the American process concentrated zinc ore is roasted, sintered, and then mixed with coal for reduction in a furnace to zinc vapor. The zinc vapor is then oxidized to zinc oxide. In the French process, the zinc after roasting and sintering is reduced to zinc metal which is vaporized and oxidized to zinc oxide.

There are variations to the American process and in a different plant zinc sinter (crude zinc oxide) is used as raw material. The zinc sinter is kiln fired in a reducing atmosphere with coal or coke. The zinc vapors released are oxidized in the combustion chamber to zinc oxide. The product is cooled, coarse particles settled out, and the rest is collected by bag filters. Part of the production is processed for sale and the rest goes to other plant processes.

In the wet process crude zinc oxide recovered from lead smelters is leached with caustic soda solution to remove sulfate and to dissolve the lead salts present. The undissolved zinc oxide is then recovered from the leaching mixtures, washed and neutralized to remove residual alkali, dried, calcined and packaged.

b. Producers

At the present time, there are five major producers of zinc oxide. Their plant locations and estimated capacities are shown in Table 114. St. Joe Mineral Corporation has announced a 45% expansion of its zinc oxide capacity bringing its total to about 80,000 tons per year. Four of these companies are zinc producers integrated forward to the manufacture of zinc oxide. One, Sherwin Williams, is integrated forward to paint manufacturing.

In addition to the companies listed in Table 114, there are a number of secondary producers who enter the market according to market demand. Their total production capacity is small and currently estimated at about 10% of that of all major producers combined. As could be expected, these companies are integrated to other metal products.

c. Manufacturing Economics

As mentioned previously, over 90% of total zinc oxide production is through dry processes which do not require water and therefore are faced with no water pollution abatement costs. Only one plant uses the wet process. We understand that this is a proprietary process and that the plant is integrated to other products.

4. Supply/Demand Balance

In mid-1972 zinc oxide was in very tight supply. This situation has continued into 1974 restraining potential demand growth. Expected capacity expansions may bring the supply/demand situation into balance. The tightness in supply has been caused primarily by the shutdown of a number of primary zinc plants. These were old plants with air pollution problems where installation of air pollution abatement equipment could not be justified. It is estimated that 700,000 tons of primary zinc capacity was closed down, and although data on the reduction of zinc oxide capacity is not available, it is believed to have been substantial. The lack of new zinc oxide capacity coming on-stream for a number of years compounded the supply problem.

5. Prices

Zinc oxide prices by type for the period 1963 to 1972 are shown in Table 115. "Actual" prices were not calculated because data for total volume and value of shipments are not available. The French process ("White Seal" zinc oxide) produces a higher quality product characterized by its brilliant whiteness, high apparent density and extreme fineness.

TABLE 114

MAJOR ZINC OXIDE PRODUCERS

Company	Location	Capacity (Thousand Tons)	Capacity (% of Total)
American Smelting & Refining Co.	Columbus, Ohio Hillsboro, Ill.	42	17.5
Eagle-Picher Industries	Hillsboro, Ill.	25	10.0
New Jersey Zinc Co.	Palmerton, Pa.	90	37.0
St. Joe Minerals Corp.	Monaca, Pa.	55	23.0
Sherwin Williams	Coffeyville, Kan.	30	12.5
Total		242	100.0

SOURCE: Industry Information

226

TABLE 115

LIST PRICES FOR ZINC OXIDE[1]

(In $/Ton)

| Year | American Process | | French Process |
	Lead-Free	Leaded Sulfate (35% Basic Lead)	White Seal
1963	260.00	277.60	300.00
1964	280.00	292.60	320.00
1965	295.00	315.00	345.00
1966	295.00	315.00	345.00
1967	305.00	315.00	355.00
1968	305.00	315.00	355.00
1969	315.00	325.00	365.00
1970	330.00	340.00	380.00
1971	350.00	345.00	400.00
1972	365.00	------	415.00

SOURCE: Chemical Marketing Reporter

Note: [1] For carlot quantities in bags, freight allowed

Prices have increased consistently at an average compound rate of 7% a year. Price changes posted in January 1974 raised lead-free zinc oxide prices by $0.008 and $0.0095 per pound, increasing it to $0.29 and $0.305 per pound ($580 and $610 per ton). In March 1974 American Process oxide was posted at $0.36 per pound ($720 per ton) and for photoconductive grade at $790 per ton, almost double the 1972 prices.

Zinc oxide prices closely follow those of zinc metal, which has been increased by 21 to 35% in 1973.

V. IMPACT ANALYSIS

A. ALUMINUM FLUORIDE

1. Treatment Costs

Total annual water treatment costs for B.P.T. and B.A.T. are estimated in the Development Document as $4.58 and $5.71 per ton, respectively. The annual cost for treatment already in place is estimated in the Development Document as $2.31 per ton. The incremental increase on an annual basis to achieve B.P.T. and B.A.T. is, therefore, $2.27 and $3.40 per ton, respectively. Consequently, B.P.T. treatment represents 0.9% of the 1972 selling price of $264.00 per ton while B.A.T. represents 1.3%. The capital investment excluding investment in treatment facilities already in place, for B.P.T. is $6.44 per ton, compared with $11.88 per ton for B.A.T. These incremental treatment facility investments represent 29.6% and 54.4% of fixed investment (at book value) for B.P.T. and B.A.T., respectively. An estimated 65% of the industry has already met the B.P.T. guideline, while 25% of the industry has met the B.A.T. standards.

2. Price Impact

We conclude that the relatively nominal (in relation to selling price) costs of water treatment, both for B.P.T. and B.A.T. standards, can be passed on as price increases. This conclusion is based on the relative absence of any conditions which might constrain higher prices. Specifically, the lack of substitute products for aluminum fluoride, the high captive usage, the relatively strong demand growth, the lack of foreign competition, the fact that each of the producers should be faced with approximately the same abatement costs, a concentrated market share distribution and the relatively few producers (four) all suggest that the industry should be able to cover the costs of water treatment through price increases.

3. Plant Shutdown Impact

Because we have concluded that prices will be increased, the question of plant shutdowns becomes academic. However, consideration of the competitive conditions in this industry suggests that even if costs could not be passed on as price increases, the likelihood of plant shutdowns is minimal. Although the after-tax treatment cost is a relatively high percent of estimated profit margins, particularly for B.A.T., the industry is highly integrated, producing plants are typically located in chemical complexes, there are no other major environmental problems, and the industry is committed to produce this product because of the strategic importance of aluminum fluoride as a fluxing agent for aluminum production.

B. BARIUM CARBONATE

1. Treatment Costs

The Development Document estimates that very nearly 50% of industry capacity is already achieving no discharge. The Development Document further estimates that 23% of the industry must invest an additional $9.55 per ton and bear incremental annual costs of $3.72 per ton to reach B.P.T. levels. The same 23% must invest $15.81 per ton in addition to treatment in-place and realize incremental annual costs of $5.99 per ton to achieve B.A.T. In comparison with the 1971 plant price of $122.80 per ton, the additional annual costs to be borne by this 23% of the industry represent 3.0% for B.P.T. and 4.9% for B.A.T.

An estimated 30% of the industry, already meeting B.P.T., must invest an additional $6.05 per ton and bear incremental annual costs of $2.00 per ton to reach B.A.T. This annual cost is 1.6% of the 1971 plant price.

2. Price Impact

There are significant constraints on barium carbonate price increases. There are a number of substitute products that could displace barium carbonate, captive usage is negligible, demand growth has been static and is not expected to undergo major changes, and price is the primary basis for competition.

Probably the major price increase constraint is the difference in water pollution abatement cost. About 50% of the industry is achieving no discharge and there is considerable discrepancy in the investment and annual cost required to achieve B.P.T. and B.A.T. for the remaining 50%. As discussed under "Treatment Costs" 23% of the industry must invest an additional $15.81 per ton to achieve B.A.T., while the remaining 30% has to invest only $6.05 per ton to achieve B.A.T. Under these circumstances about 50% of the industry will not have any additional cost, 30% will have only an increased annual cost representing 1.6% of the 1971 plant price of $122.80 per ton, while the remaining 23% will bear a total additional annual cost of 4.9% of its 1971 plant price.

However, the industry has undergone a restructuring in the past few years. Subsequent to the drastic drop in demand resulting from strontium carbonate's displacing barium carbonate in its major end use (television glass), two companies, one of which had 50% of total industry plant capacity, chose to shut down, and others converted part of their barium carbonate capacity to strontium carbonate. As a result the industry, which was confronted with considerable overcapacity, found itself unable to meet domestic demand. Tightness in the supply/demand balance increased imports and firmed domestic prices.

The three barium carbonate producers that remain are aware of the limitation of their market and future potential. As a result, they are

very slowly and cautiously adjusting capacity to meet domestic demand. Under these circumstances of tight supply/demand balance, limited number of producers and a static but rather firm market, manufacturers will be in a position to pass on the increased costs resulting from water pollution abatement measures.

It is important to note that the three manufacturers are geographically dispersed. The ability to pass on price increases will be enhanced by the differences between producers in transportation cost of raw materials and finished product.

3. Plant Shutdown Impact

Given our conclusion that treatment costs will be passed on through higher prices, it is unlikely that manufacturers will elect to shut down plants. There is insufficient capacity to supply the domestic market and the industry cannot afford to lose another producer. About two-thirds of the industry is represented by multi-industry companies in locations where there is a relatively high level of integration. The remaining one-third is represented by a privately-owned company.

All barium carbonate is manufactured in chemical complexes and manufacturers are confronted with some air pollution problems in addition to water pollution. All producers have considerable emotional commitment to the manufacture of barium carbonate, and the segment of the industry mostly affected by abatement cost may have to absorb part of the increase in cost and pass on the rest.

C. BORIC ACID

1. Treatment Costs

Incremental water treatment costs for boric acid are reported in the Development Document as $0.83 annually per ton of product for both B.P.T. and B.A.T. This applies to those plants producing mined borax; production of boric acid from lake brines by the Trona process results in no discharge and thus no treatment costs. At $0.83 per ton, annual treatment costs represent 0.8% of the 1972 plant price of $104 per ton.

2. Price Impact

The treatment costs for boric acid are likely to be passed on in the form of price increases. There are only three producers of mined borax so that a modest price increase to cover higher treatment costs is likely, even though the one producer utilizing the Trona process will not have treatment costs.

Demand will not be sensitive to a small price increase, as supply is currently tight (capacity utilization was around 90% in 1972). Tight

supply has in fact hindered growth of the market; this will continue to be true for the near future. Thus the historic low growth in demand will not act as a price increase deterrent. There is a moderate amount (20 to 30%) of captive usage, so in some areas there is an opportunity for price increases in boric acid to be passed on by the producer via derivative products which use boric acid as a raw material.

3. Plant Shutdown Impact

Even without the ability to pass on higher treatment costs, it is unlikely that there would be boric acid plant shutdowns. There are no other significant environmental problems resulting from the manufacture of boric acid. Producers of boric acid have a commitment to boric acid and would be unlikely to shut down even a marginal situation. This is true despite the fact that the producers are multi-industry companies. The plants are each part of a chemical complex so there would be other products over which to spread the cost of treatment facilities. Another factor which would also act in favor of maintaining production is the high backward integration. More importantly, the after-tax treatment costs are small relative to estimated profits (20% for both B.P.T. and B.A.T.) and the treatment facilities investment is minimal (2% for both B.P.T. and B.A.T.) in comparison with estimated net fixed investment (book basis).

D. CALCIUM CARBONATE (PRECIPITATED)

1. Treatment Costs

As presented in the Development Document, total annual water treatment costs per ton for precipitated calcium carbonate are $3.12 for B.P.T. and $4.94 for B.A.T. This applies to the process of manufacture from either the carbonation of lime or from the Solvay process wastes. Of this amount, 100% of the industry is already experiencing annual costs of $2.08 per ton, so the incremental cost is $1.04 for B.P.T. and $2.87 for B.A.T. The incremental B.P.T. costs, therefore, represent 1.7% of the $61.60 per ton 1972 plant price. Similarly, the incremental B.A.T. costs represent 4.6% of the 1972 price.

2. Price Impact

There are several industry conditions acting to constrain price increases. Captive usage is low, with the exception of two paper companies who manufacture PCC. While demand growth has been moderate, capacity utilization has been low (60 to 70%). Another constraining factor is the relatively fragmented market share distribution. Finally, the existence of substitute products in the major applications for precipitated calcium carbonate places an upper limit on the magnitude of any price increases.

Other factors which are compatible with a price increase for calcium carbonate, however, include the fact that foreign competition is low, abatement costs are equal, and the basis for competition includes

product quality (property differences) as well as price. Moreover, there are presently only four merchant producers. With the possible future shutdown of synthetic soda ash operations, it is believed that at least one calcium carbonate plant operating in conjunction with Solvay process soda ash facilities will shut down (assuming no shift to the carbonization of lime process). With the expected consolidation of the industry, price increases would be more easily obtained. An increase is supported by the low ratio of before-tax treatment costs to selling price: viz., 1.7% for B.P.T. and 4.6% for B.A.T.

3. Plant Shutdown Impact

Although we have concluded that the relatively modest (in comparison to plant prices) treatment costs will be passed on through price increases, we have also examined the forces tending to force or retard plant shutdowns.

The several reasons for plant shutdown in the industry include: a high ratio of after-tax treatment costs to after-tax net income for B.A.T. (58.5%); low forward integration to other end-use products; a relatively indifferent emotional commitment; and ownership in the hands of multi-industry companies. On the one hand, reasons for continuing operations include: a positive cash flow (even if treatment costs are absorbed); the ratio of investment in treatment facilities to net fixed investment (book) is low for B.P.T. (2.5%) and low to moderate for B.A.T. (10.1%); and high backward integration. As previously stated, we anticipate that at least one precipitated calcium carbonate facility associated with a synthetic soda ash plant will shut down where and if the soda ash plant is shut down. The soda ash plant will shut down as a result of competitive forces in the sodium alkali industry.

E. CALCIUM HYDROXIDE

According to the Development Document there are no water treatment costs associated with the conversion of quicklime to calcium hydroxide (hydrated lime). Consequently, there should be no price impacts or plant shutdowns for calcium hydroxide based on wastewater considerations.

However, as discussed in a previous impact study on the inorganic chemicals industry (EPA-230/2-74-015) there are water effluent costs for some production of quicklime. More specifically, those quicklime plants using wet scrubbers to remove entrained dust from plant stack gases face treatment costs of $1.28 per ton annually. The previous study concluded that although a few such plants would be in a position to pass on all of the added treatment costs, most of the lime plants currently using wet scrubbers would have to absorb all or nearly all of the added costs. Because of the relatively low profitability levels in the lime industry, it was concluded in the previous study that from 4 to 10 quicklime plants would be closed as a result of these wastewater treatment costs.

F. CARBON DIOXIDE

1. Treatment Costs

Total annual water treatment costs for both B.P.T. and B.A.T. are estimated in the Development Document as $0.13 and $0.80 per ton, respectively. Therefore, B.P.T. treatment represents 0.4% of the estimated 1972 selling price of $28.59 per ton while B.A.T. represents 2.8%. An estimated 10% of the industry is already meeting the B.P.T. requirements.

2. Price Impact

We conclude that the low cost of water treatment in relation to selling price, for both B.P.T. and B.A.T. standards, can be passed on as price increases. This conclusion is based on the relative absence of conditions which might constrain higher prices, viz. lack of substitute products, relatively high capacity utilization (seasonally adjusted), high demand growth, low foreign competition, equal abatement costs among producers, a relative insensitivity of demand to price, and a concentrated market share distribution (three producers account for 75% of total capacity).

3. Plant Shutdown Impact

Although we have concluded that treatment costs will be passed through as price increases and that consequently there will be no plant shuddowns, an examination of plant shutdown considerations suggest that some plant shutdowns would be possible if treatment costs had to be absorbed.

The reasons for this are due primarily to the large number of producing plants (55) owned by a relatively few producers. The producers may be committed to carbon dioxide in general but not to an individual producing plant. Therefore, in the event that an individual plant--particularly, a high cost plant--is unable to pass on treatment costs and therefore faces reduced profits, the producer can shut down this particular plant without compromising his commitment to the product or seriously jeopardizing his position in the industry.

G. CARBON MONOXIDE

1. Treatment Costs

Total annual water treatment costs for B.P.T. and B.A.T. are estimated in the Development Document as $0.14 and $4.98 per ton, respectively. Therefore, B.P.T. treatment represents 0.1% of the estimated 1972 selling price of $124.00 per ton while B.A.T. represents 4.0%. An estimated 60% of industry has achieved B.P.T. standards but no one in the industry has reached B.A.T.

234

2. Price Impact

We conclude that the low cost (in relation to selling price) of water treatment for both B.P.T. and B.A.T. standards can be passed on as price increases. This conclusion is based on the existence of industry conditions which might permit higher prices, namely: (1) few substitute products; (2) high capacity utilization; (3) relatively high captive usage; (4) high demand growth; (5) low foreign competition; (6) equal abatement costs among producers; and (7) concentrated market share distribution.

Aside from price as the basis for competition, the only constraint on price increase might be the fairly large number of producers (12).

3. Plant Shutdown Impact

Since we have concluded that prices will be increased, the question of plant shutdowns becomes academic. However, even if costs could not be passed on there is little likelihood of plant shutdown because the industry is committed to produce this product due to its importance in the production of oxo-alcohols and acetic acid. That is, in spite of the relatively high ratio of treatment facilities investment in comparison with estimated net fixed investment (82% for B.A.T.), we believe the captive requirements for carbon monoxide in downstream products would compel the industry not to shut down plant facilities.

H. CHROME PIGMENTS

1. Treatment Costs

The Development Document indicates that attainment of B.P.T. standards for chrome pigments will result in annual costs of $18.00 per ton. Similarly, achievement of B.A.T. standards implies total annual costs of $18.63 per ton. In comparison to the estimated average 1972 plant price of $900 per ton, the respective B.P.T. and B.A.T. costs represent 2.0 and 2.1%. (If the treatment costs are compared to the range of 1972 plant prices--$764 per ton for chrome yellow and orange to $1,308 per ton for iron blue--B.P.T. represents 1.4 to 2.4% and B.A.T. represents 1.4 to 2.4%.) An estimated 30% of the industry has achieved the B.P.T. standard.

The capital investment requirement for B.P.T. facilities is indicated as $117.94 per ton while the B.A.T. investment is $119.27 per ton. These treatment facilities investments represent 78.6% and 79.5% of estimated net fixed investment for B.P.T. and B.A.T., respectively.

2. Price Impact

The constraints against price increases for chrome pigments include a relatively high level of foreign competition, a low level of captive usage, a relatively fragmented market with many producers, and the existence of substitute products. On the other hand, there are no major abatement cost differences between producers, capacity utilization is good, and demand growth has been fair. Most significantly, however,

235

since the price increase necessary to cover treatment costs is only slightly more than 2% of the estimated average 1972 plant price, we conclude that it will be possible to increase prices to cover treatment costs.

3. Plant Shutdown Impact

The qualitative considerations impacting on the plant shutdown decision are fairly evenly balanced between those which argue for an those which argue against plant closures if water treatment costs had to be absorbed. Specifically, the lack of either forward or backward integration, the fact that most pigment facilities are not located in large complexes where treatment costs could be shared, and the existence of OSHA problems in addition to water pollution concerns all weight the decision in favor of plant shutdown. On the other hand, the fact that many of the pigment producers are smaller companies with relatively low diversification (prompting our judgment that commitment to continued production of chrome pigments is relatively high) argues for continued plant operation.

The purely economic considerations in the plant shutdown decisions are similarly balanced. If treatment costs could not be passed on through price increases, the impact on after-tax margins would not be severe (the after-tax treatment costs for both B.P.T. and B.A.T. represent approximately 18-19% of estimated 1972 after-tax margins). As a result, cash flow would remain positive even if treatment costs had to be absorbed. On the other hand, the ratio of investment in treatment facilities to net fixed investment is high (approximately 79% for both B.P.T. and B.A.T.). On balance, the net effect of all of these considerations is neither clearly for not clearly against plant shutdown. However, since we believe that the treatment costs can be recovered through price increases, we have concluded that the chrome pigment industry will not be faced with plant shutdowns.

I. COPPER SULFATE

1. Treatment Costs

The Development Document provides water treatment costs for both the "waste recovery" and "pure" process routes to copper sulfate production. For the waste recovery process, capital costs for B.P.T. are estimated at $0.55 per ton with total annual costs of $0.63 per ton. The Development Document estimates that 90% of the industry using the waste recovery method already has the B.P.T. investment in place. For B.A.T., the treatment investment for the waste recovery route would be $6.15 per ton and annual costs would total $2.07 per ton. In comparison with the $427.00 plant price reported for 1971, this B.P.T. annual cost represents 0.2% and the B.A.T. annual cost represents 0.5%.

For the "pure" (i.e., scrap) process, the capital investment was estimated at $0.73 per ton for both B.P.T. and B.A.T. with total annual costs at $0.14 per ton. This annual cost represents 0.03% of the 1971 selling price.

236

2. Price Impact

Price constraints on copper sulfate are significant primarily because of the high occurrence of substitute products, the lack of captive usage, a relatively static demand, and the many producers in a relatively small market. Furthermore, competition is based on price and there is a high price elasticity of demand. Consequently, although capacity utilization is adjustable to demand, foreign competition is low and the market is concentrated in four major producers, there are major constraints on price increases in copper sulfate. In spite of this, copper sulfate prices increased by about 20% from 1973 to February 1974 and will likely increase again. Copper represents 25% of the total weight of copper sulfate, making copper sulfate prices dependent on copper availability and world prices.

Compared to copper scrap prices which increased from $0.49 to $0.50 per pound in May 1973 to $0.86 to $0.87 per pound in May 1974 (a 75% increase), the copper sulfate price increase necessary to cover water treatment costs is insignificant. For the companies using the waste recovery method, the total annual cost to achieve B.P.T. represents 0.2% of the 1971 plant price and 0.5% of the same price to achieve B.A.T. For companies using the "pure" process, the total annual cost to achieve both B.P.T. and B.A.T. is 0.03% of the 1971 plant price. We thus conclude that the copper sulfate industry will be able to pass on the nominal cost increases resulting from water pollution abatement measures.

3. Plant Shutdown Impact

Copper sulfate manufacturing plants will not shut down as a result of water pollution abatement costs, which we have concluded will be passed on as price increases. The largest producers are multi-industry companies with high backward integration (the unit manufacturing copper sulfate is part either of a chemical- or metal-producing complex) and there are no other environmental problems in addition to water pollution. Producers, however, are fairly indifferent to copper sulfate production and they may curtail or shut down operations if copper sulfate margins are reduced as a result of high copper prices.

In the past, small producers have been able, because of the nature of the process, to reduce or temporarily discontinue production of copper sulfate depending on market price and raw material availability and price. The equipment could frequently be utilized for temporary manufacturing of other chemicals. This practice will occur again if higher copper prices (or unavailability) force copper sulfate prices to levels where substitute products begin to encroach on copper sulfate end-use markets. However, the requirements to make additional investment in water pollution abatement equipment may discourage small producers from reopening their operation when market conditions improve again. In any event any production curtailment or plant shutdown decision by the industry will be as a result of raw material price increases rather than as a result of water pollution abatement costs.

J. FERRIC CHLORIDE

1. Treatment Costs

Capital investment requirements for ferric chloride waste treatment facilities for both B.P.T. and B.A.T. are estimated by the Development Document to be $0.75 per ton. Similarly, total annual costs for both B.P.T. and B.A.T. are estimated at $2.25 per ton. In comparison with the 1972 plant price of $78.00 per ton, the B.P.T. and B.A.T. annual treatment costs represent 2.9% of revenue. An estimated 10% of the industry is already meeting the B.P.T. and B.A.T. standards.

2. Price Impact

Price increase constraints for ferric chloride are high. There are a number of substitute products that threaten to replace ferric chloride on a price basis. Captive usage is low, as is capacity utilization. Utilization of existing capacity will decrease over time as the steel and titanium dioxide industries search for alternate, and if possible, profitable ways to dispose of their ferrous and ferric chloride by-product. It is possible that increased capacity from these new lower cost sources will result in lower ferric chloride prices in spite of the relatively high demand growth rate and the absence of foreign competition.

We have defined abatement costs as being unequal since they will affect companies manufacturing ferric chloride by the iron-chlorine process differently than potential producers from steel and titanium dioxide wastes. Since we believe the trend is toward lower prices and since the basis for competition is price in a market where price elasticity of demand is high, companies currently manufacturing ferric chloride by the iron-chlorine process will not be able to pass on the annual costs for B.P.T. and B.A.T. even though these costs represent only 2.9% of the 1972 selling price for sewage-grade ferric chloride. Moreover the two companies using the iron-chlorine process, who had about 55% of the total market in early 1974, are at an increasing manufacturing cost disadvantage in view of the less expensive raw material position enjoyed by companies manufacturing ferric chloride from ferrous chloride by-product or as a waste by-product from titanium dioxide operations.

3. Plant Shutdown Impact

The two companies which produce ferric chloride from iron and chlorine are expected to curtail or shut down their operations as a result of new industry economics when sufficient capacity from alternative processes becomes available (presumably, prior or concurrent to the 1977 B.P.T. deadline). We believe, however, that these plants would have shut down even without the imposition of the new water effluent costs.

The plants affected by price constraints and shut down decisions have a low degree of integration but they are owned and operated by multi-industry companies and are located in chemical complexes. There appears

238

to be varying degrees of commitment on the part of manufacturers. Other environmental problems, in addition to water pollution, are minimal but these factors, together with a positive cash flow and a low ratio of investment in treatment facilities to net fixed investments, will not be sufficient to prevent plant shutdowns as a result of industry overcapacity and new low prices.

On the basis of estimated dollar value of 1972 shipments from the affected plants and assuming the same ratio of dollar value of shipments to total employment as that reported in the 1972 Census of Manufactures for the Miscellaneous Inorganics Chemical Industry, the two plants have total employment of 50 to 75 people. Employees at one of the plants might be reassigned to other facilities within the complex. Employees of the second plant, located in a large metropolitan area, should be able to find employment in other area industries.

K. HYDROGEN CYANIDE

1. Treatment Costs

Hydrogen cyanide is produced in a direct process (Andrussow process) and as a by-product from acrylonitrile production (Sohio process). According to the Development Document production of hydrogen cyanide as a by-product of acrylonitrile production leads to no wastes or water treatment costs attributed directly to hydrogen cyanide.

One treatment approach for the Andrussow process production of hydrogen cyanide entails capital costs and annual costs for both B.P.T. and B.A.T. of $12.57 and $4.17 per ton, respectively. This annual cost represents 1.8% of the 1972 selling price. The Development Document indicates that no one in the industry has as yet achieved these standards for this treatment approach. However, 54% of the industry was reported to have spent $11.43 per ton in capital investments and was incurring $3.67 per ton of annual treatment costs for an intermediate level of water treatment.

Finally, another approach to water treatment for Andrussow process hydrogen cyanide involved a capital investment of $44.90 per ton and annual treatment costs of $14.00 per ton for both B.P.T. and B.A.T. This annual cost represents 6.1% of the 1972 selling price. The Development Document indicates that 23% of the industry had already achieved this level of treatment.

2. Price Impact

The overwhelming consideration in the examination of the impact of water treatment costs on hydrogen cyanide is the extremely high captive usage in the industry. In 1972, for example, 70% of production was reported by the Commerce Department as being consumed in the producing

239

plant. At least another 10% of production was represented by inter-plant shipments among producers. Therefore, at least 80% of hydrogen cyanide produced in 1972 was consumed captively. Based on this high captive ratio and the relatively modest price increase necessary to cover treatment costs (for both B.P.T. and B.A.T., 1.8% or 6.1% of the 1972 list price depending upon the specific treatment approach used), we conclude that hydrogen cyanide prices will be increased to cover treatment costs.

We have come to this conclusion in spite of the relatively low capacity utilization, demand growth which is static at best, and the fact that production via the Sohio process incurs no water treatment costs at all. We believe the atypically high captive usage outweighs these considerations which would normally act as constraints on price increases.

3. Plant Shutdown Impact

Because we have concluded that treatment costs will be passed on through price increases, we anticipate no plant shutdowns among hydrogen cyanide producers. However, even if prices could not be increased to cover costs, it is unlikely that any producing plants would be shut down. For an estimated 77% of production via the Andrussow process the after-tax cost of treatment represents only 18% of the estimated after-tax unit profits, and the investment in new treatment facilities is slightly less than 10% of the net fixed plant investment (book value). That is, the economic pressures are insufficient to cause plant shutdowns for this segment.

For the remaining 23% of Andrussow process production, after-tax treatment costs represent 53% of after-tax profits and the treatment facilities investment is 34% of net fixed investment. However, these treatment facilities are already in place.

Moreover, industry conditions are such that plants would continue to operate even with slightly greater economic penalties. As previously indicated, there is extremely high forward integration to derivative products. Hydrogen cyanide production is typically located in larger chemical complexes. The need for hydrogen cyanide as an intermediate for downstream products and the relative lack of substitute products or processes leads to relatively high levels of industry commitment to continued hydrogen cyanide production.

L. LEAD MONOXIDE

1. Treatment Costs

Total annual treatment costs for B.P.T. and B.A.T. are reported in the Development Document as $2.27 per ton. The annual cost for treatment facilities already in-place by the entire industry is estimated in the Development Document as $0.08 per ton. The incremental increase on an annual basis to achieve B.P.T. and B.A.T. is, therefore, $2.19 per ton.

Consequently, incremental B.P.T. and B.A.T. treatment costs represent 0.6% of the 1972 selling price of $333 per ton. The capital investment in treatment facilities required to meet both B.P.T. and B.A.T. standards is estimated in the Development Document to total $9.34 per ton. Because 100% of the industry has invested $0.12 per ton for treatment in-place, the incremental investment to attain B.P.T. and B.A.T. is $9.22 per ton.

2. Price Impact

We conclude that the low cost of water treatment, measured as a percent of selling price for B.P.T. and B.A.T. standards, can be passed on as a price increase. This conclusion is based on the existence of conditions which should not constrain higher prices, e.g., the lack of substitute products for lead monoxide, high capacity utilization, good demand growth, lack of foreign competition, equal abatement costs among producers, concentrated market share distribution, and the relatively few significant producers (three).

3. Plant Shutdown Impact

Probably the major concern in the consideration of plant shutdowns for lead monoxide is the relatively high ratio of investment in treatment facilities to net fixed investment (44%) considered in the context of an industry which is only marginally profitable (1.0 to 1.5% after-tax return on sales). That is, producers will be faced with the need to increase their net fixed investment by very nearly 50% with no improvement in profit margins if prices are increased only sufficiently to cover treatment costs. We conclude, therefore, that prices will have to increase somewhat more than the amount necessary to cover water treatment costs in order to justify new investment in treatment facilities. We believe that competitive conditions are such that such a price increase is possible. Lead monoxide producers are primarily large, multi-industry companies with access to the capital market. We believe, therefore, that capital availability would not be an insurmountable problem insofar as treatment facilities investment is concerned.

It is important to point out, however, that lead monoxide producers are faced with other environmental pressures in addition to water treatment, particularly OSHA. In addition, some of the producers have several plants so that single plants could be closed without the producer having to abandon an industry position entirely. We would categorize any such actions on individual plants, however, as base-line closures. That is, any such closures would be prompted by competitive conditions in the industry and by other environmental problems and not directly as a result of water treatment costs.

M. MANGANESE SULFATE

1. Treatment Costs

The Development Document estimates that annual treatment costs to achieve B.P.T. will be $4.65 per ton, with a capital investment of $9.71 per ton of annual production required for treatment facilities. The B.P.T. annual costs represent 5.0% of the 1972 selling price. Plants representing an estimated 86% of industry production have achieved the B.P.T. standard.

The Development Document estimates that annual treatment costs to achieve B.A.T. will be $30.26 per ton, with a capital investment of $79.37 per ton of annual production required for treatment facilities. The B.A.T. annual costs represent 33% of the 1972 selling price, and are potentially large enough to result in negative profitability for some producers.

2. Price Impact

We believe that producers will be able to pass along most, if not all treatment costs. Three factors are significant in this regard:

(1) A price increase for manganese sulfate does not appear to be constrained by the presence of manganous oxide as a substitute. Price is currently the only basis by which these two products compete. Manganous oxide contains almost twice as much elemental manganese as manganese sulfate but costs only $8 to $10 per ton more. However, the efficacy of manganese sulfate as a micronutrient is markedly superior to that of manganous oxide. Therefore, on a basis of manganese available to the crop, manganese sulfate is more cost effective, and users are willing to pay for this superiority. Industry sources report that manganese sulfate prices could be as high as $150 per ton with no detrimental effects on demand.

(2) The amount of costs which some plants will have to pass along might possibly not be the full amount estimated by the guidelines contractor. Since these plants are in complexes, treatment of manganese sulfate water wastes will probably be combined with that of other chemicals produced in the complex. Unit treatment costs for manganese sulfate should thereby be reduced. More importantly, since the production costs for manganese sulfate are allocated to it from the overall production of hydroquinone, the producers have some latitude as to where manganese sulfate treatment costs will be incurred—either solely by manganese sulfate, or jointly with hydroquinone.

(3) Moderating the above mentioned price and cost flexibility, however, is the fact that one plant reports that it already employs a zero-discharge water waste handling system and will thus incur no additional costs for water treatment. The other plants in the industry, faced with increased costs, may be limited in the price increase they can seek by the presence of a competitor with potentially large capacity which can offer product unburdened by treatment costs. This potential constraint on price increases, along with low apparent capacity utilization, low captive usage, and static demand, is outweighed in our judgment by factors which would allow price increases, viz. the lack of substitute products, low foreign competition, and the concentrated market.

3. Plant Shutdown Impact

We do not envision plant shutdowns as the direct result of water effluent treatment costs. First and foremost, most if not all of the treatment costs will be passed on through price increases. Moreover, as long as the by-product manganese sulfate producer remains in the hydroquinone business, he will continue to produce manganese sulfate. Only if the costs of treating water effluent from manganese sulfate recovery and purification are greater than those of disposing all the manganese sulfate produced during hydroquinone production will the producer discontinue manganese sulfate recovery. As pointed out in the price impact section, it is expected that treatment costs for manganese sulfate will most likely to shared with other products produced in the complex. That likelihood, combined with the cost allocation latitude mentioned earlier, makes it unlikely that wastewater treatment costs of manganese sulfate recovery and purification will exceed those of disposing of all manganese sulfate by-product.

The economic considerations--after-tax treatment costs and treatment facilities investment in comparison with profit margins and net plant investment, particularly for B.A.T., as well as the negative cash flow for B.A.T.--favor plant closings. However, the negative economics would prevail only if prices could not be increased.

N. NICKEL SULFATE

1. Treatment Costs

The Development Document estimates B.P.T. costs (1) for a large plant in a complex (2) for a large isolated plant, and finally, (3) for a small isolated plant. In the first case, i.e., a large plant located in a complex, the capital investment for B.P.T. is $1.48 per ton and the annual costs are $1.71 per ton. An estimated 50% of the industry is indicated to have made this investment and to be experiencing these annual costs, which represent 0.23% of the reported 1972 plant price of $744.00 per ton.

For a large plant not located in a complex, the capital investment for B.P.T. is estimated at $4.44 per ton with annual operating costs of $2.49 per ton. This B.P.T. annual cost represents 0.33% of the 1972 plant price ($744.00 per ton).

A small isolated plant would have to invest $62.13 per ton and experience annual costs of $45.61 per ton. This annual cost represents 6.1% of the 1972 plant price.

Investment and annual operating costs for B.A.T. for all three types of plants are estimated at $29.31 per ton and $17.91 per ton, respectively. The B.A.T. annual cost represents 2.4% of the 1972 plant price.

2. Price Impact

The constraints on nickel sulfate price increases are moderate to high. Nickel sulfate has, practically speaking, no chemical substitute in its major application, metal plating, but nickel-plated parts face increasing competition by stainless steel or plastic materials. Capacity utilization currently is high and foreign competition low but consumption of nickel sulfate has plateaued and is expected to decline over the long term. The plating industry, as a result of restrictions on the metal content of their effluent, may begin to recycle or reclaim nickel sulfate. The process is expensive and only large platers may be in a position to economically install recycling systems. However, if nickel salt prices continue to increase, recycling may become more economical.

Captive usage of nickel sulfate is about 10%, not enough to have a major influence on other factors tending to constrain price increases. An important price increase constraint is the unequal abatement cost difference affecting the industry. Depending upon whether nickel sulfate is manufactured in a large plant located in a complex, in a large isolated plant, or in a small isolated plant, the capital investment to achieve B.P.T. varies from $1.48 per ton to $4.44 per ton to $62.13 per ton and the annual cost from $1.71 per ton to $2.49 per ton to $45.61 per ton. About 50% of total production is manufactured by a large plant in a chemical complex which already has made the required investment to achieve B.P.T. Large isolated plants will undertake the required investment since the B.P.T. annual cost represents only 0.33% of the 1972 plant price of $744.00 and that could be easily passed on. But the small company with an isolated plant may not be in a position to invest $62.13 per ton and sustain an annual cost of $45.61 per ton which represents 6.1% of the 1972 plant price. Even if the small plant went directly to B.A.T. treatment (annual costs of $17.91 per ton), it would be operating at a significant cost disadvantage to the large producers.

In an industry where competition is based on price, the market is concentrated in a couple of producers, and future demand growth is expected to be static or decline, the price constraints on the small manufacturer are very high and he may be faced with a plant shutdown

decision. For large manufacturers price constraints and costs are sufficiently small for these companies to pass on the water pollution abatement costs as price increases to achieve B.P.T. and B.A.T.

3. Plant Shutdown Impact

Plant shutdown is likely for the small producer but not for the large manufacturers. Although the different producers all are multi-industry companies and would continue to show a positive cash flow, the ratio of after-tax treatment cost to after-tax net income is high for the small producer (61.3% at B.A.T. levels) relative to the large ones (2.3 to 3.4% at B.P.T. levels). Also the ratio of investment in treatment facilities to net fixed investment is high (29.3% at B.A.T. levels) versus 0.7% and 2.0% for the large ones at B.P.T. Furthermore, the industry has a low level of integration, faces air pollution problems in addition to water effluent problems and there probably is an indifferent attitude on the part of the small manufacturer. Thus the large producers, not really confronted with price constraints and in addition, being committed to the manufacture of this product will not shut down plants. For the small producer it is unlikely that interest in nickel sulfate will be sufficiently strong to avoid a plant shutdown.

This shutdown candidate represents an estimated 10% of industry productive capacity. We believe the remaining producers will be able to increase production to make up the difference. An estimated 15 to 20 employees would be affected as a result of the plant shutdown. We believe that most of these employees could be reemployed in other facilities of the company. There is also the possibility that the facilities for nickel sulfate could be converted to production of other inorganic materials in which case the employees could probably be used for that purpose. We do not anticipate any significant community impact as a result of this plant shutdown.

O. POTASSIUM PERMANGANATE

1. Treatment Costs

The single producer of potassium permanganate is indicated in the Development Document to have already invested $10.25 per ton in treatment facilities and to be experiencing annual costs of $3.10 per ton. To reach B.P.T. standards, the company must invest an additional $0.41 per ton with an increase in annual costs above treatment in place of $0.05 per ton. The additional $0.05 per ton annual treatment costs represent less than 0.01% of the estimated 1972 selling price of $760 per ton.

To achieve B.A.T. standards, the potassium permanganate producer must increase capital investment above treatment in place by $59.59 per ton and experience annual costs of $27.13 per ton above treatment in place. The additional operating costs for B.A.T. represent approximately 3.6% of the 1972 plant price.

2. Price Impact

The demand for potassium permanganate, in general terms, is not price sensitive since it is used in relatively small amounts in each one of its end uses. It is characterized by excellent oxidizing ability and there are few products that can effectively substitute for potassium permanganate in most of its applications. Although captive use is low, current capacity utilization is high, and demand is growing. Its only producer has a very aggressive marketing department which bases its sales and promotion on technical services and market development. Price increases have been within the limits necessary to maintain foreign competition at low levels.

The manufacturer of potassium permanganate will be able to pass on water pollution abatement costs as price increases. This producer has already invested $10.25 per ton in treatment facilities and has only as additional investment of $0.41 per ton to achieve B.P.T. standards. This additional investment will represent less than 0.01% of the estimated 1972 selling price of $760 per ton.

The additional annual costs required to achieve B.A.T. represent approximately 4% of the 1972 plant price. Since previous price increases, on the order of 15 to 20% of the previous price, did not appear to adversely impact market demand for potassium permanganate, this additional cost will also be passed on.

3. Plant Shutdown Impact

Since price increase constraints are negligible the manufacturing company will not be confronted with a plant shutdown decision. In any event, even though potassium permanganate is manufactured in an isolated plant with a low level of integration and is confronted with some sludge disposal problems in addition to water pollution, the company is family-owned and their emotional commitment to this operation is high. It is unlikely that the owners would shut the plant down even if the treatment costs had to be absorbed.

P. SILVER NITRATE

1. Treatment Costs

The Development Document has estimated B.P.T. and B.A.T. treatment costs on an annual basis for silver nitrate at $3.73 per ton and $78.23 per ton, respectively. If these treatment costs are converted to av. oz. (the unit of measure commonly used in the silver nitrate industry), the corresponding B.P.T. and B.A.T. treatment costs become $0.000117 per av. oz. and $0.00244 per av. oz., respectively. An estimated 100% of the industry has already achieved B.P.T. levels, while none of the producers were at B.A.T. levels according to the Development Document.

As a percentage of the mid-year 1972 list price of $0.91 per av. oz., the cost of B.P.T. is 0.013% and the cost of B.A.T. is 0.27%. As compared to the estimated 1972 after-tax profit margin of $0.01 per av. oz., the incremental after-tax cost to achieve B.P.T. standards is 0.58% while achievement of B.A.T. standards would represent 12.2% of 1972 unit margins.

2. Price Impact

Almost all factors which might act to constrain price increases for the existing silver nitrate producers are missing and the situation suggests that price increases to cover water treatment costs are possible. Silver nitrate prices move directly with the price of silver, if the silver is not supplied by the purchaser of silver nitrate. More typically, however, the silver is supplied by the silver nitrate purchaser in which case conversion prices are the customary route for merchant silver nitrate operations. Conversion prices are related to cost of conversion and should not be constrained in moving upward to compensate for increased effluent treatment costs. We conclude, therefore, that the full cost of water treatment control will be passed on as either price increases, or, more likely, as conversion cost increases.

3. Plant Shutdown Impact

In recent years two producers of silver nitrate have discontinued production. Even if water treatment costs were not passed on through higher conversion charges or as price increases, the three remaining producers are unlikely to be influenced by the resultant reductions in after-tax unit profit margins to a degree which might cause plant shutdown. Two of the three producers have strong captive markets for silver nitrate in their basic photographic film businesses. The third producer likewise has captive requirements for the production of silver catalysts and plating solutions. The third producer also plans to expand capacity in 1975. Silver nitrate is essential to the basic businesses of all three manufacturers and is in short supply. Significant deterioration of silver nitrate profit margins due to effluent treatment is not expected. Plant shutdowns due to effluent treatment costs are therefore unlikely.

Q. SODIUM BISULFITE

1. Treatment Costs

Total annual water treatment costs for B.P.T. and B.A.T. are estimated in the Development Document as $3.97 and $4.46 per ton, respectively. Therefore, B.P.T. treatment represents 2.8% of the estimated 1972 selling price of $140.00 per ton while B.A.T. represents 3.2%. The capital investment in treatment facilities required to meet B.P.T. standards is $9.94 per ton versus $10.13 for B.A.T. However, 75% of the industry has already invested $6.21 per ton as partial fulfillment of the facilities requirement and is spending $2.52 per ton annually.

2. Price Impact

We conclude that the low cost of water treatment, in relation to selling price, for both B.P.T. and B.A.T. standards can be passed on as price increases. This conclusion is based on the relative lack of substitute products, the high capacity utilization, the lack of foreign competition, approximately equal annual abatement costs for the producers, the concentrated market share distribution and the fact that there are only two major producers.

3. Plant Shutdown Impact

Since we have concluded that prices will be increased, there will be no plant shutdowns. However, even if costs had to be absorbed, there would probably be no shutdowns since the economic penalty of so doing would be relatively modest. Moreover, the industry is integrated back to raw materials, plants are located in chemical complexes, and there are no other major environmental problems.

R. SODIUM HYDROSULFIDE

1. Treatment Costs

The Development Document indicates that annual costs for sodium hydrosulfide to meet B.P.T. and B.A.T. standards are $2.47 and $12.42 per ton, respectively. In comparison with the reported 1972 unit value of $107.25 per ton, the annual costs represent 2.3% and 11.6% of per-ton revenues.

The capital investment shown in the Development Document for B.P.T. and B.A.T. are $13.15 and $26.49 per ton, respectively. One producer, representing 6% of the industry, is already meeting the B.A.T. guideline. In addition, according to the Development Document, one producer representing very nearly 40% of the industry is discharging into a municipal system. (Contractor estimates indicate that this producer has slightly less than 20% of industry capacity.) Finally, several producers, representing very nearly 80% of the direct dischargers, have invested $1.74 per ton in treatment facilities and are experiencing annual costs of $0.34 per ton.

2. Price Impact

The constraints against price increases for sodium hydrosulfide are relatively high. The industry is operating at a relatively low rate of apparent capacity, captive usage is low, and substitute products exist in many applications. Conversely, however, foreign competition is not a problem, demand has been increasing slowly, and perhaps more importantly, the Development Document indicates that there are no significant abatement cost differences between producers (with the exception of the producer discharging to the municipal system who will not experience B.A.T. costs).

248

For the B.P.T. level, the price increase necessary to recover treatment costs is modest (2.3%). While it is true that the B.A.T. cost as a percent of the 1972 plant price is more significant (11.6%), the current list price for sodium hydrosulfide is up significantly from 1972 levels ($225 per ton versus $151 per ton). We conclude that costs will be passed on through higher prices.

3. Plant Shutdown Impact

If costs had to be absorbed at the expense of profit margins, the impact would be severe and indications are that plants would be shut down, particularly at B.A.T. levels. For B.A.T., the after-tax cost of treatment would essentially cancel the estimated 1972 profit margin per ton. The investment in treatment facilities as a percent of estimated fixed investment is relatively high (74.9% for B.A.T.). Integration is low and ownership is largely in the hands of multi-industry companies that would have other and presumably more attractive investment opportunities. For that reason we have assumed that on balance the commitment of producers to sodium hydrosulfide is low. However, as indicated in the preceding paragraphs, since we believe that prices will be increased to cover treatment costs, we do not anticipate plant shutdowns as a direct result of proposed water effluent guidelines.

S.   SODIUM HYDROSULFITE

1.   Treatment Costs

The Development Document indicates that total annual costs for B.P.T. treatment of sodium hydrosulfite are $1.09 per ton. The comparable B.A.T. costs are $5.62 per ton. In comparison to the 1972 plant price of $446, the B.P.T. cost represents 0.2% and B.A.T. cost represents 1.3% The Development Document further indicates that 50% of the industry already has B.P.T. treatment facilities in place.

The corresponding capital investment levels for B.P.T. and B.A.T. are $3.11 and $12.48 per ton, respectively. Fifty percent of the industry has made an initial investment of $3.10 per ton in treatment facilities.

2.   Price Impact

The constraints against price increases for sodium hydrosulfite are nominal. Although substitute products exist (indirectly by virtue of new fibers and new dye technologies which might have a negative effect on textile industry consumption of sodium hydrosulfite), captive usage is essentially nill, and demand growth has been modest, the other considerations in our matrix suggest that prices could be increased. Specifically, capacity utilization is high, foreign competition is low, the price elasticity of demand is low and the market is concentrated among a relatively few producers. This lack of constraints on price increases considered in conjunction with the relatively small price increase

on a percentage basis necessary to cover costs (0.2% for B.P.T. and 1.3% for B.A.T.) leads us to the conclusion that producers will be able to pass on treatment costs in the form of higher product prices.

3. Plant Shutdown Impact

Even if the nominal price increase necessary to cover costs could not be made, the arguments for plant shutdown are weak. The economic penalty of having to absorb costs is minor for both B.P.T. and B.A.T. (considering costs as a percent of margin and treatment facilities investment as a percent of net fixed investment). There are no major environmental problems in addition to water treatment. The bulk of industry capacity is in the hands of smaller companies whose commitment to sodium hdyrosulfite is deemed high by virtue of the fact that they would appear to have fewer options for alternate investment opportunities than multi-industry chemical companies.

T.   SODIUM SILICOFLUORIDE

1. Treatment Costs

The Development Document esimates annual treatment costs for sodium silicofluoride production at $7.06 per ton for B.P.T. and $11.66 per ton for B.A.T. B.P.T. involves treating all process wastewater with lime and settling out the suspended solids prior to water discharge. According to the Development Document, all operating silicofluoride plants presently achieve this treatment level. B.A.T. control involves B.P.T. with subsequent evaporation of clarified water to eliminate all effluent wastewater. This additional evaporation step represents the difference of $4.60 per ton between B.P.T. and B.A.T. Two-thirds of the industry is presently achieving B.A.T. wastewater control.

Annual costs for B.P.T. treatment represents 6.1% of the 1972 sodium silicofluoride selling price of $116.67 per ton; on the same basis, B.A.T treatment is determined to be 10.0%. The estimated after-tax profit margin for silicofluoride is $7.38 per ton of product. Giving credit for the B.A.T. treatment already in place, the incremental after-tax treatment cost for achieving wastewater control is calculated to be 0% for B.P.T. and 31.2% for B.A.T. when compared to the unit profit margin.

2. Price Impact

A review of price factors affecting sodium silicofluoride suggests that the constraints on a price increase to cover added treatment costs are not dominating. Although price is the basis for competition and there is a fragmented market share distribution, a static to declining market, and substitute products exist, which all point to constraints on price increases, these factors are not overwhelming when compared to

overall market conditions. With little foreign competition, equal treatment costs for each producer, substantial silicofluoride captive usage, and a relatively inelastic relationship of price to demand, the domestic silicofluoride market should be flexible enough to bear the moderate price increases necessary to cover B.A.T. costs. This conclusion is even further reinforced by our contention that substitute materials for silicofluoride applications must undergo similar treatments for effluent purity and would therefore be affected by similar added costs.

The industry seems able to absorb the effects of effluent treatment since it is reported that all of the industry is currently operating at the B.P.T. level and two-thirds at the B.A.T. level. Most associated costs have, therefore already been absorbed or passed along into the selling value.

3. Plant Shutdown Impact

Consideration of plant shutdown for sodium silicofluoride is largely academic as the pricing scheme appears flexible enough to absorb both levels of treatment costs.

However, an estimated positive cash flow (including treatment costs), substantial forward and backward integration with phosphoric acid plants, and 45% captive usage all preclude any plant shutdown due to imposed effluent treatment costs.

U. SODIUM THIOSULFATE

1. Treatment Costs

Annual treatment costs to meet B.P.T. standards for sodium thiosulfate manufacturers are estimated in the Development Document to be $4.31 per ton. Similarly, B.A.T. treatment costs on an annual basis are estimated at $8.10 per ton. The Development Document indicates that 7% of the industry has achieved both B.P.T. and B.A.T. An estimated 35% of the industry had achieved a lesser level of treatment (essentially vacuum filtration) at an annual cost of $3.54 per ton. The B.P.T. and B.A.T. annual costs represent 3.8% and 7.2%, respectively, of the 1972 plant price of $112.69 per ton for those producers not achieving vacuum filtration. For 35% of the industry the incremental costs are $0.77 and $4.56 per ton for B.P.T. and B.A.T.

The total capital investment required to meet B.P.T. standards was estimated at $16.60 per ton versus $26.94 per ton for B.A.T. The incremental investment for the 35% of the industry is $2.09 per ton for B.P.T. and $12.43 per ton for B.A.T. In comparison with the $22.50 per ton net fixed investment (book value) estimated for the industry, the B.P.T. and B.A.T. investments represent 73.7% and 120% of net fixed plant.

2. Price Impact

On balance, factors constraining price increases for the merchant sale of sulfur dioxide outweigh those factors suggesting that price increases are possible. Specifically, the low capacity utilization, the low captive usage of the producers for merchant sale (captive production and use of sulfur dioxide by paper mills, for example, is not included in the merchant sulfur dioxide industry), the low demand growth, the high volume of imports, the unequal abatement costs (one producer has no wastewater problem), and price as the primary basis for competition all mitigate against price increases unless capacity utilization remains high. We conclude, therefore, that the cost of water treatment control (at both B.P.T. and B.A.T. levels) for all merchant producers will not be passed on as price increases.

3 Plant Shutdown Impact

In view of the conclusion that additional water treatment costs must be absorbed by some producers, there is a possibility that one or two plants may be closed. The probability for plant shutdown is greatest where the recovery of merchant sulfur dioxide is not directly related to a pollution control process of sulfur removal from stack gases. The incremental investment ($600,000 to $700,000 for a 40,000 ton-per-year plant) for water treatment control is high in comparison to investment in an existing plant. This high investment may not be critical if the production of sulfur dioxide for merchant sale is concommitant with the necessity for removal of sulfur from stack gases, but for five of seven plants where such may not be the case the economics of continued production may be unfavorable.

The two plants most likely to close have aggregate capacity which represents less than 15% of total industry capacity. However, since the industry in 1972 was operating at only approximately 50% of capacity there should be no supply problems as a result of closure. Depending upon whether only one or both plants are closed, from 15 to 30 people would be affected. The affected employees should have opportunities for reemployment within the company or companies. Community impacts should be minimal.

W. ZINC OXIDE

1. Treatment Costs

The Development Document estimates investment requirements to achieve B.P.T. for production of zinc oxide via the wet process at $9.07 per ton with annual costs of $5.17 per ton. The Development Document further indicates that the one producer using this process has already achieved this level of treatment. Achievement of B.A.T. standards would require a total investment of $16.87 per ton and total annual costs of $7.67 per ton. The B.P.T. annual costs represent 1.4% of the $365.00 per ton 1972 list price, while the B.A.T. costs represent 2.1%. The incremental investment to achieve B.A.T. is $7.80 per ton.

VI. LIMITS TO THE ANALYSIS

Implicit in the analysis are a number of critical assumptions primarily with regard to the economic parameters upon which the impact judgment was based.

A. TREATMENT COSTS

Aside from the accuracy of the treatment cost estimates taken from the Development Document, a key assumption (with a few exceptions) that for any given type of treatment for any segment, unit treatment costs do not vary with plant size.

B. PLANT PRICES

Where available, the plant prices used in this report are as calculated from Commerce Department data using the dollar value of total shipments in 1972 divided by total shipments tonnage. In the contractor's experience they are the most accurate and most meaningful indications of industry prices--certainly more meaningful than list prices. They do reflect, however, a weighted average for all reporting companies and include discounts from list, contract and volume discounts (where appropriate) and freight allowances and freight equalizations (where appropriate) all of which vary from producer to producer. Consequently, the single value number we have used in our analysis for the 1972 price for any segment may not agree exactly with the plant price realized by any individual producer in that segment.

C. COST/PRICE COMPARISON

One of the parameters used in our impact analysis is the ratio of 1971 treatment costs with 1972 plant price to make the judgment of the impact of treatment costs in 1977 and 1983. The implicit assumption bearing on the validity of that ratio is that treatment costs and plant prices will inflate at the same rate.

D. MANUFACTURING COSTS AND PROFIT MARGINS

With one or two exceptions, the manufacturing costs used to estimate industry profit margins are estimates by the contractor. They attempt to model manufacturing economics for each segment and do not

VII. PRESCREENING PRODUCTS

One of our initial tasks was to review the entire list of in-
organic chemicals (Phase II). Where the annual cost of treatment was low
relative to selling price, the total dollar volume of investment required
for treatment facilities was low, and/or 100% of the producers in the
segment had already achieved B.A.T. standards, we felt justified in
eliminating those segments from detailed study on the basis that there would
be no impact on the segment as a result of abatement costs or that the
impact would be minimal.

According to the Development Document, the following segments
have zero costs:

chromic acid   hydrogen
ferrous sulfate   trona

Producers in three segments have already achieved B.A.T. standards,
including:

borax
potassium chloride, and finally
sodium fluoride (anhydrous neutralization process only)

For another group of the prescreening products, the annual cost
of both B.P.T. and B.A.T. treatment was small as compared to the 1972
selling price (less than 1%), and the total investment in treatment
facilities (crediting the capital cost of treatment in place) for the en-
tire segment was small (less than $110,000). In our judgment producers
in these segments should be able to increase prices the nominal amount
necessary to cover water treatment costs. Even if all costs were not
covered by price increases, the impact on profit from the absorbed costs
would not be sufficient to cause plant shutdowns. Included in this
group are:

Ammonium Hydroxide

The Development Document indicates that annual water treatment
costs for ammonium hydroxide for both B.P.T. and B.A.T. are $0.08 per
ton. These costs represent 0.1% of the estimated 1972 selling price
($80 per ton). The capital investment in water treatment facilities re-
quired for ammonium hydroxide are $0.23 per ton for both B.P.T. and
B.A.T. The total water treatment facilities investment for the entire
industry, therefore, will be $0.01 million.

257

Conversely, large producers of strong nitric acid would have annual costs of $0.36 per ton for B.P.T. and $0.67 per ton for B.A.T. Assuming that 15% of total productive capacity is represented by small producers the total industry annual costs for B.P.T. treatment represent 0.04% of the 1972 selling price, while the annual costs of B.A.T. treatment represent 0.08%.

The Development Document further indicates that the capital investment in water treatment facilities for a small producer for both B.P.T. and B.A.T. would be $1.81 per ton while that for a large producer would be $0.36 per ton. On a total industry basis the capital investment required for treatment facilities for both B.P.T. and B.A.T. for strong nitric acid would be $0.11 million. However, according to the Development Document, five plants are known to be producing significant quantities of strong nitric acid so that the investment per plant would be nominal.

Potassium Iodide

The Development Document indicates that of the two plants producing potassium iodide, one, which represents approximately 33% of industry production, has no discharge. The second plant, accounting for 67% of industry production, discharges through a municipal sewer. Assuming that pretreatment requirements for municipal sewer discharge would be equivalent to B.P.T., this plant would have annual costs of $2.79 per ton and an investment in treatment facilities equivalent to $5.44 per ton. As a percent of the 1972 selling price ($4,612.94 per ton) the annual costs for B.P.T. represent 0.04% and the total annual investment would be $0.004 million.

Zinc Sulfate

According to the Development Document, two-thirds of production has no wastewater effluent requiring treatment. The remaining one-third of industry production faces annual costs of $0.68 per ton for both B.P.T. and B.A.T. representing 0.46% of the 1972 selling price. The capital investment for B.P.T. and B.A.T. for this one-third of the industry is $4.15 per ton, equivalent to $0.06 million total investment.

The remaining prescreening products did not meet the treatment cost/selling price ratio or total treatment facilities investment criteria, but were not considered for in-depth analysis for the following reasons.

Ammonium chloride

According to the Development Document, only one plant, producing ammonium chloride as a by-product from a Solvay soda ash facility, faces water treatment costs. Other producers of ammonium chloride use a dry process with no treatment costs or produce ammonium chloride as a by-product or organic processes which are not covered in this guideline.

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16. Abstracts

     An analysis of the economic impact of proposed water effluent guidelines upon 28 inorganic chemicals was performed based on water treatment cost data supplied by the EPA. The inorganic chemicals included aluminum fluoride, barium carbonate, boric acid, calcium carbonate, calcium hydroxide, carbon dioxide, carbon monoxide, chrome pigments, copper sulfate, ferric chloride, hydrogen cyanide, lead monoxide, manganese sulfate, nickel sulfate, silver nitrate, sodium bisulfite, sodium hydrosulfide, sodium hydrosulfite, sodium silicofluoride, sodium thiosulfate, sulfur dioxide, and zinc oxide. A methodology was developed to systematically judge the broader economic effects on these chemicals, resulting from application of water effluent control, first by assessing the likelihood that treatment costs would be defrayed through price increases, and secondly, if price increases were not likely, the likelihood that plant shutdowns would occur. Based on this approach and using the treatment costs supplied, it was concluded that plant shutdowns would occur for ferric chloride, nickel sulfate, and sulfur dioxide if either best practicable technology or best available technology standards were imposed on these industries.

17. Key Words and Document Analysis.   17a. Descriptors

    Economic Analysis
    Effluent Guidelines
    Inorganic Chemicals
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17b. Identifiers/Open-Ended Terms

17c. COSATI Field/Group

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